Skin Stories
Charting and Mapping the Skin
Research using analogies of human skin tissue in relation to my textile practice

Being a Thesis presented by

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ABSTRACT

The practice based research SKIN STORIES :: CHARTING AND MAPPING THE SKIN deals with issues across the fields of art, design, technology, biology and material science. In an attempt to bridge the gap between aesthetics and technology by investigating the potential of new and industrial materials, the epidermis is used as a metaphor for creating innovative textile surfaces which behave, look or feel like skin. As a result of theoretical enquiry and practical experiments, interactive design solutions have been developed to a prototype stage for possible application in domestic environments and public spaces as well as for integration into body related design concepts. The development of such functional and interactive textile membranes will hopefully enable individuals to experience a polysensual and responsive environment and it is this aspect which is considered to be an original contribution to knowledge in the textiles field.

The aim of this written thesis is not only to illustrate the journeys and investigations made along the way and to demonstrate the outcome of the research, but also to situate the practical work in its cultural, critical and technological context. This thesis is accompanied by an interactive CD-ROM which is a visual representation of my 'research map' and holds a record of the practical work carried out during the research project.

The ideas of the project SKIN STORIES :: CHARTING AND MAPPING THE SKIN have been developed and tested during a 3-year research programme towards a Ph.D. at The London College of Fashion, University of the Arts London.

THESIS CONTENT

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INTRODUCTION

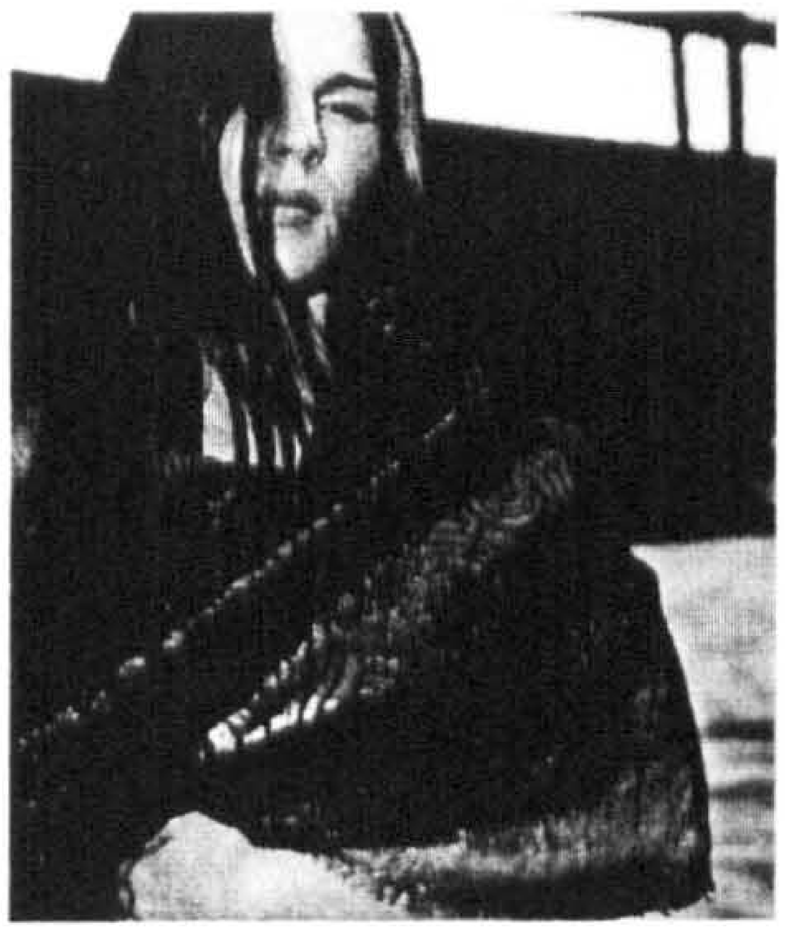
'Death, like life, is not a momentary event but is an ongoing process whose traces line the body. At the point where I make contact with the world, I am always already dead.'[1] *Mark C. Taylor*

The whole body can be looked on as an extended network. This is a self-regulating system that governs both the internal conditions of an organism - by controlling bodily aspects such as temperature, glucose levels and many others - and the external environment, which the organism can influence by its behaviour. Within this context the skin plays an important role, being the first outpost of the body. 'The skin forms a self-renewing and self-repairing interface between the body and its environment, and is a major site of intercommunication [...] between the two.'[2]

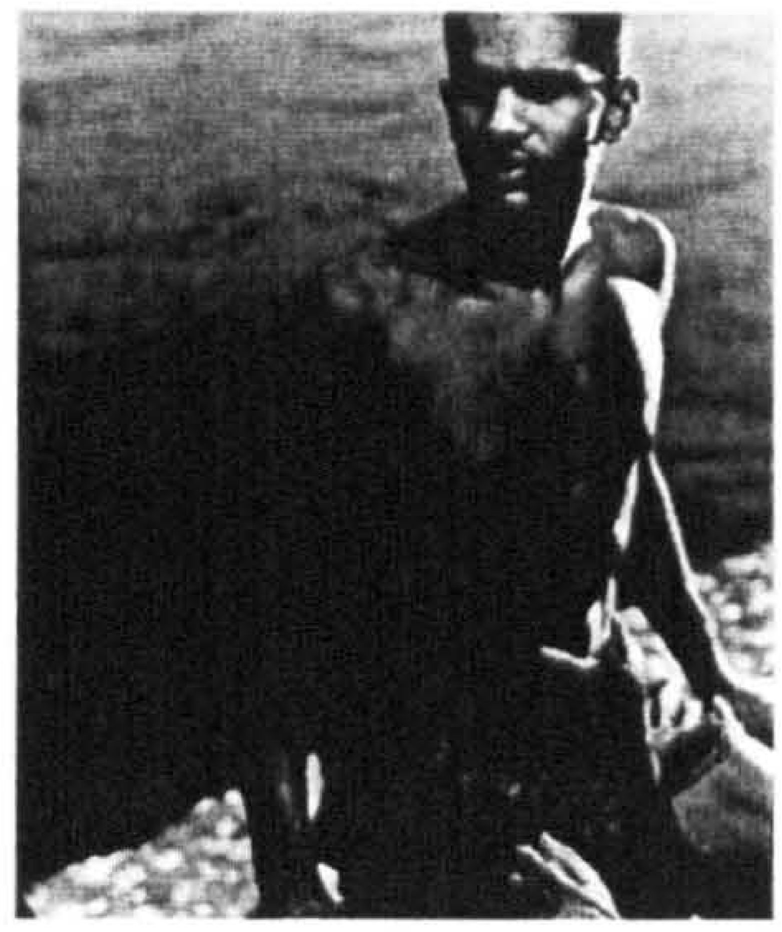
Skin is a complex genetic phenomenon and represents personal and social identity. Besides being an essential component for our existence, it is a physical and psychological barrier marking the boundary at which our body starts and also ends. It protects the internal body and provides evidence of our private history. In fact, skin may be viewed as the fabric of the body.

The skin is our largest organ and it is vitally important for our existence. Without skin, the human body would be unprotected and unable to survive. This sheltering envelope is in fact a phenomenon of nature in respect of its biological organisation and relationship between its structures and functions. 'Here [...] a number of different body systems come together in synergy to fulfil general overall functions beyond their individual specialized functions.'[3] Skin provides us with an impressive example of an intelligent approach to problem solving by working interdisciplinary. At various levels, there are many lessons we can learn from the skin in order to engineer and design new surfaces and products. 'If someone had invented skin, they would be hailed as one of the great designers of all time.'[4]

Skin is a barrier between the inner and outer world, the private and the public, a microcosm and a macrocosm. It is the container or mask of the underlying human spirit and reminds us of our mortality. Because of its materiality it represents our separation from the outer world. However, skin is also our point of contact with the outer world and is responsible for our tactile experiences and perceptions. It is the only sense organ, which has the capacity to function simultaneously in two directions by registering incoming stimuli and communicating our feelings to the outer world.



1 Fabric MANA, MA collection Tattoos, 1999.



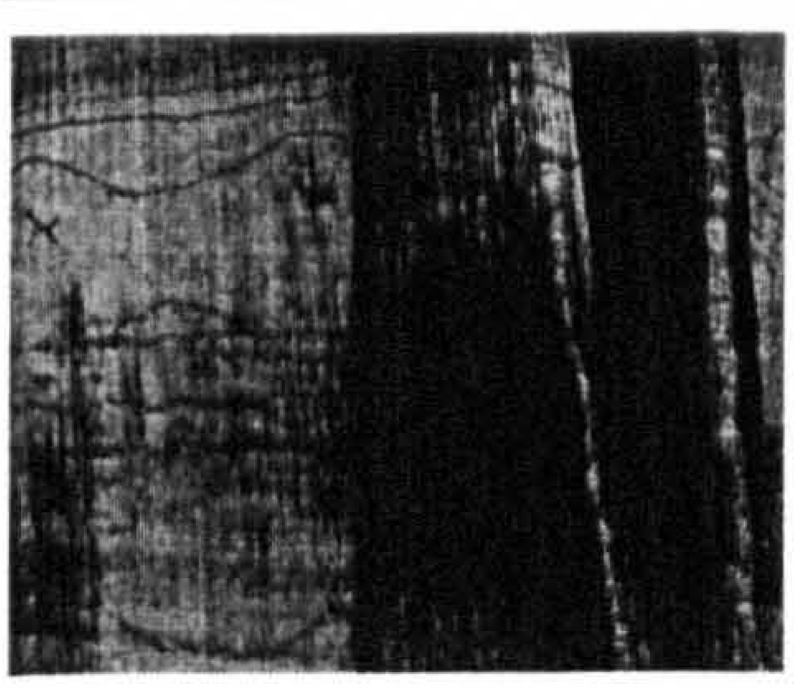
2 Fabric TAHITI, mixed media textile collection Tattoos, 1999.

3 Fabric POLYNESIA, MA collection Tattoos.

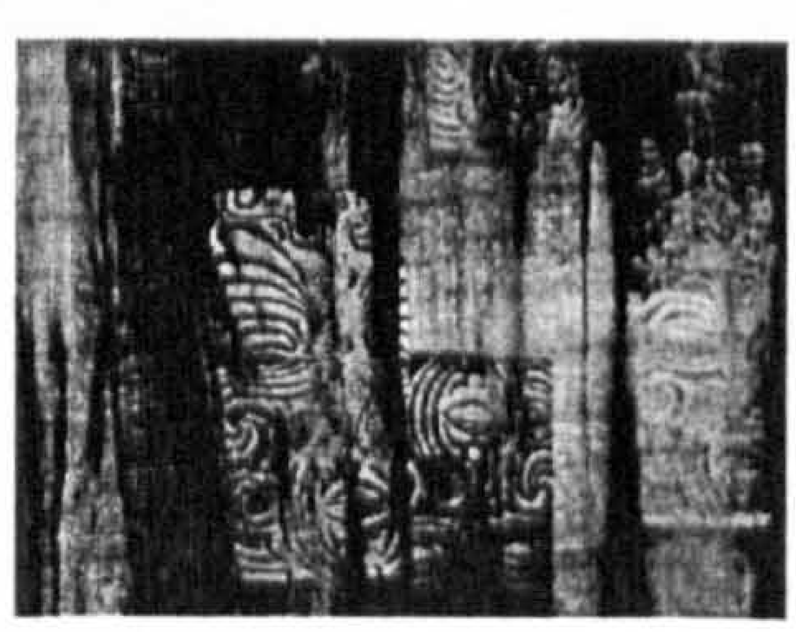
4 Fabric TAONGA, mixed media textile collection Tattoos.

5 Fabric NEW ZEALAND, MA collection Tattoos, 1999.

6 Fabric POLYNESIA, detail.



7, 8 Fabrics SAMOA and WAIATA, details.



9, 10 Fabric MOKO with a detail, MA collection Tattoos, 1999.

11 Fabric PACIFIC, mixed media textile collection Tattoos, 1999.

PRACTICE EVOLUTION MAP

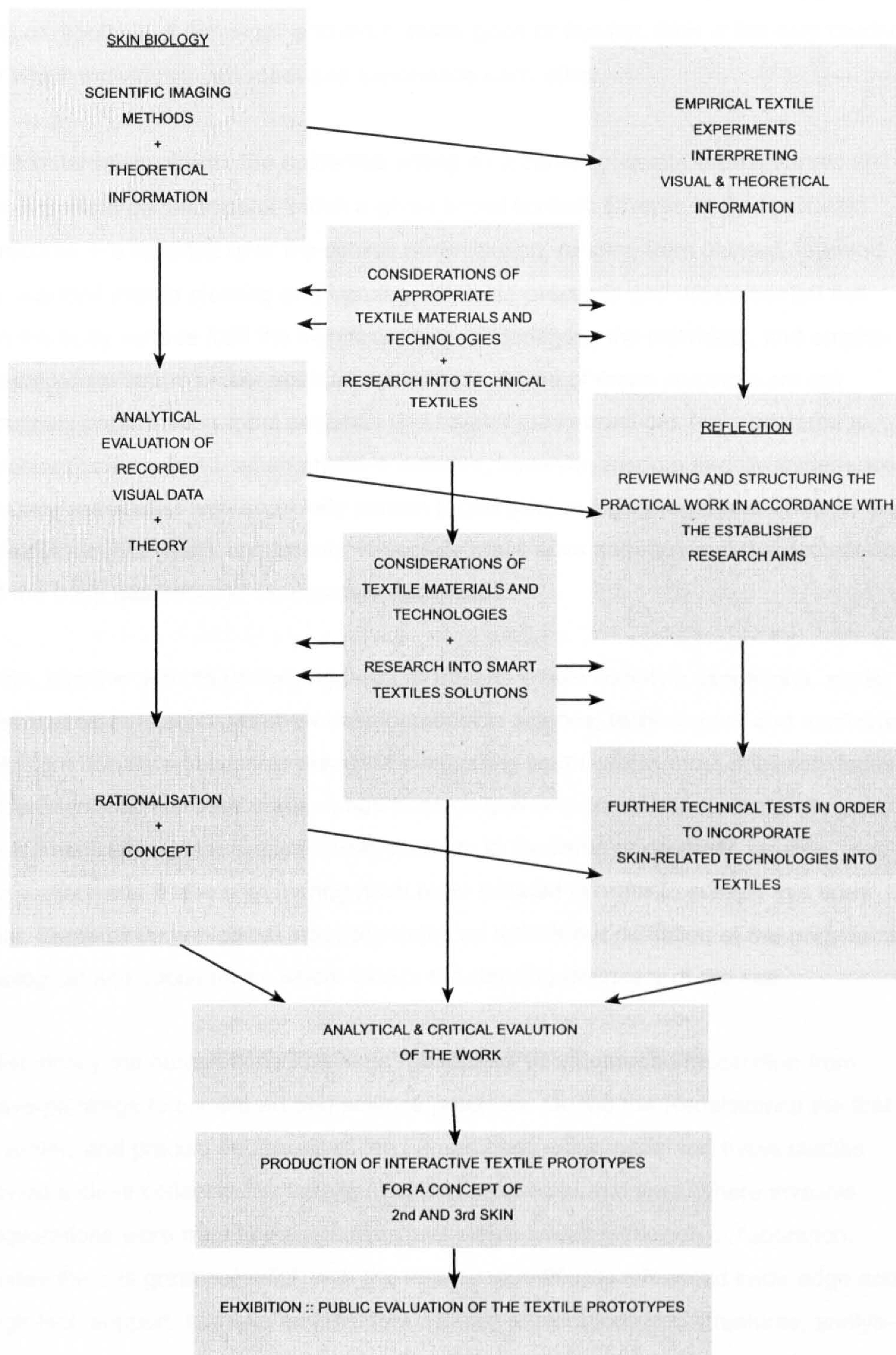


Table 1
Practice Evolution Map.

This is not characteristic of any other of the sense organs – eyes, ears, nose, mouth. It also has an aesthetic appeal and therefore can be visually and somatically pleasing or repulsive, it can smell and even 'taste' good or familiar. Skin is the very border at which individuals can meet and experience each other.

The outer layer of skin, the epidermis acting as a carrier of social codes, serves as an important communicator within a given social context. Diverse body decoration practices are reported over the course of civilisation, ranging from painted, tattooed or scarified skin to piercing and burning. All these practices and rituals carried out on the body surface fulfil the significant role of identifying the individual, and emphasising social status and/or spiritual convictions. Some of these practices are still routinely performed in tribal societies and indeed many practices have migrated to Western culture. In so-called primitive cultures, however, wisdom and life experience, usually associated with an elderly person (aged skin) is highly regarded. While in the Western world, 'youth and beauty' is socially more advantageous and the perception of the body has become increasingly superficial.

Skin, together with its underlying body, is the site where society's aspirations, anxieties and fears interact with new developments in science, technologies and medicine. Western society's obsessive dream of everlasting youth, which most obviously focuses primarily on the body surface, has become one of a prime targets in the progress of biomedical science. Endless developments in the fields of cosmetic science, plastic surgery and tissue engineering have been initiated in order to sustain this body cult. Some biotechnological practices make us rethink our definition of the body as a biological and social entity, where skin is the defining boundary of the self.

Historically the human body has been the subject of widespread fascination from cave-paintings to current art and science practices. During the Renaissance the first scientific and precise depictions of the human body were made and these studies reveal a close collaboration between art and science at that time, where invasive explorations were made by anatomists and artists working in close collaboration. Today there is great potential, with the help of scientifically advanced knowledge and high-tech support, to make increasingly detailed explorations into structures, analysing the human body's physical phenomena. This reveals another exciting dimension of the biological body, including 'landscapes' of the skin, which from a designer's perspective are of particular interest in my research inquiry coupled with my textiles practice.

My fascination with the human skin and its semiotics started while I was doing my MA degree at the University of Arts in Berlin. I was working on a textiles collection inspired by Pacific tattoo designs and body decoration (Fig. 1 - 11). After studying the skin as a surface on which people literally inscribe their personal and social values, I felt a need to take the next step into the 'depth' of the skin, in order to investigate its physicality and its biological mechanisms with the aim of translating these phenomena into a textiles vocabulary following the principles of biomimetic design.

My particular interest, when working on the project SKIN STORIES :: CHARTING AND MAPPING THE SKIN, was to examine this living fabric from the textile designer's point of view in order to use it as an analogy for my creative practice. Its layers and structures, its multi-functionality and complexity and at the same time its tremendous simplicity, fascinated me during the entire research project. The 'technology' of the skin, how it is engineered by nature and responds to external and internal stimuli, was the inspiration behind the development of my textiles.

The construction and responsive nature of the skin was investigated and recorded through the use of scientific microscopic imaging systems and biological skin slides. The possibility of zooming into tiny forms and shapes, magnified surfaces, structures and details, usually hidden from sight, introduced another, fascinating dimension to the skin, revealing its great depth. This visual information, accompanied by theoretical enquiries on the functions of skin and the survey conducted on appropriate materials for my textiles practice, all served as a rich source for new design solutions, which in one way or another embody the characteristics of skin. This research ultimately resulted in a series of interactive textile prototypes for a concept of 2nd and 3rd skin, whereby clothes are identified with the '2nd skin' and environment is interpreted as the '3rd skin' (see Table 1, Practice Evolution Map).

The written body of work is divided into two parts: Identification of Skin and (Re)working the Skin through the Medium of Textiles (see Table 2, Research Map), which are followed by Appendices A - D. Part I is concerned with the skin as a biological and social phenomenon as well as with the symbolism of skin in art, design and scientific practices. In the Identification of Skin the subject of enquiry is placed in its cultural, critical and technological context. Part II is devoted to my experimental design practice leading to the development of new responsive textile surfaces with selected skin-like qualities.

In Chapter 01 – Research Aims and Scope are discussed, but Chapter 02 is concerned with the Research Methods. The Part I begins with Chapter 03 - Skin as Social Canvas where the epidermis is discussed as a carrier of social codes. It is in this chapter where some contents from my MA thesis have been partly integrated in a revised form. Chapter 04 – Biological Skin deals with skin's properties and functions. Sensory Skin is described in Chapter 05. Skin as Interface for Science, Art and New Technologies is explored in Chapter 06. In Chapter 07 – Textiles – the Engineered 2nd and 3rd Skin the various aspects of functional, technical and medical textiles incorporating certain skin-like qualities and functions are discussed. The principles of biomimetic design in relation to skin as a 'technology' are also explored. A survey of all these topics has informed the development of my creative practice.

Chapters 08 to 14 in Part II – (Re)working the Skin through the Medium of Textiles deal with the practical aspects of the research. The design brief, designing methods, materials, technologies, processes, experiments, aesthetics and outcomes are discussed. Furthermore, the results of the practice based research project SKIN STORIES :: CHARTING AND MAPPING THE SKIN are analysed and an evaluation of the final exhibition is given.

RESEARCH MAP

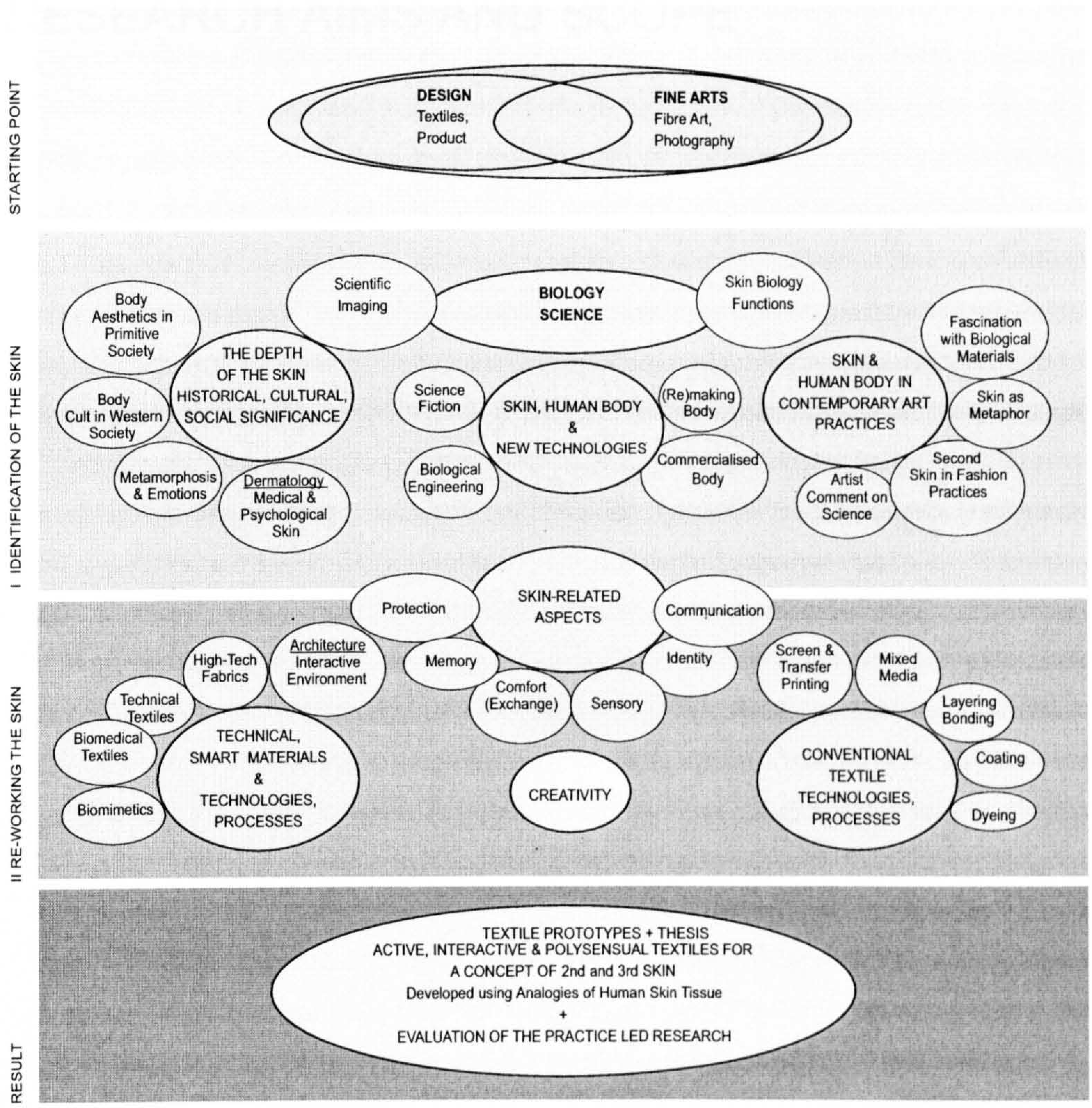


Table 2
Research Map.

CHAPTER 01 ::

RESEARCH AIMS AND SCOPE

01 RESEARCH AIMS AND SCOPE

New and smart materials as well as intelligent use of low-tech materials provide extensive evidence of the potential for the entire textile industry - in the fashion and clothing sector, in the interiors sector, as well as in the technical textiles. Specialists are predicting that in the near future, our very day-to-day lives will be significantly enhanced and regulated by intelligent devices and processes. Many of those systems will be incorporated into textiles. These future developments will be the result of active collaboration between professionals from a whole variety of backgrounds and disciplines: engineering, science, design, process development, business and marketing.

In recent decades there has been greatly increased development within the technical and intelligent textiles area. Within the last decade in particular, an escalating interaction between textile design, technology and science can be observed. The cross-fertilisation of diverse ideas from various backgrounds stimulates the extensive potential for developing new design products and engineering processes. In this context, design has a particular role as mediator between technological innovation and real living environments.

The principal objective of this practice led research project was to investigate new design possibilities for interactive mixed-media textile surfaces, using analogies of human skin tissue in relation to my own textile practice. As indicated in the original research proposal the aims of the investigation were:

- to examine the technical and practical processes within textile design by focusing my practice-led research on biological and medical aspects of human skin and body surface, in particular scientific imaging, magnified anatomical structures and textures, its physical characteristics
- to translate these phenomena into a textiles vocabulary and following the principles of biomimetic design, combine aesthetic and functional aspects of skin characteristics
- to develop and test new applications and technologies within textile design that arise from the research, particularly focusing on aspects of membrane and display, which embodies protection, identity, communication

- to develop mixed media textile surfaces as a result of the process of scanning and mapping the surface of the body, using practical simulation of the skin's physical and functional characteristics into fabrics by means of bonding, layering, 3D-moulding, heat setting and various print processes
- to produce a body of textile works accompanied by a written thesis

The main idea of this body of work was to develop functional and responsive textile membranes that enable individuals to experience a polysensual and interactive environment. It was anticipated that the new design concept should respond to people's needs, enable them to enhance their sense of wellbeing and offer them the possibility of interacting with their surroundings by creating an ambience consonant to their own requirements at any particular moment. The scope for technical experiments was established in order to facilitate incorporation of selected aspects of functionality and to contribute to new knowledge within this field.

Selected properties of the skin were translated into a textiles vocabulary by identifying a range of textile-related technologies. In order to do this, the structures and functions of human skin tissue were examined from the perspective of a textile designer as stated below:

- exploration of the potential of textiles as latent heating systems to control the room temperature (the analogy of skin being a thermo-regulator)
- examination of the thermochromic properties of textiles as indicators of fluctuating conditions in the interior (the analogy used is that of human skin reactions to physical and psychological stimuli - skin as sensor and biochemical mechanism)
- investigation of the interactive and decorative potential of thermochromic and touch-sensitive surfaces to exploit transient skin images and patterns (the analogy used is skin as a sensor)
- exploration of the olfactory and filtering potential of textiles as deodorising, anti-microbial and curative surfaces (analogy - skin as immunological surveillance and biochemical mechanism)

CHAPTER 02 ::

RESEARCH METHODS

02 RESEARCH METHODS

In order to set my own creative work in its cultural, critical and ethical context I have conducted a survey of the human skin in relation to our (bio)technological reality. This included a focus on contemporary art and design practitioners working with biological materials and body-related issues. For my research the ethical aspect became particularly important since I was actually working on and with the substance which is the very border of the human body, physically and symbolically embodying its dignity, by practically using biological human skin specimens and skin casts.

A comparative study of body aesthetics in primitive cultures and body cult in western society was also undertaken with references to design and art practices where skin has been used as a metaphor in order to discuss issues related to body and identity. Topics reviewed cover skin biology, sensorium, skin as social phenomenon, science fiction, scientific and technological developments in the fields of biomedicine, material science, textiles engineering and recent developments in textile, fashion and product design including architecture.

In order to chart the progress of new mixed-media textile surfaces, I have surveyed current textile developments, concentrating on certain materials and technologies in the field of technical textiles. In particular I have focused my research on industrial, smart and performance materials for textiles applications including high-tech clothing, architectural membranes and textiles created following the principles of biomimetic design. Apart from reading specialist information and researching on the Internet, this has been achieved by attending subject-related conferences and exhibitions such as 'Material_Experience', 'Material_Vision', 'Techtextil', 'Avantex', 'INTEDEC' and by contacting many companies and research institutions. These include the Institute of Textile Technology and Process Engineering Denkendorf in Germany, the Fraunhofer Institute for Applied Polymer Research in Berlin, the Institute for Biology and Zoology, Freie Universität Berlin, the Herriot-Watt University, School for Textiles and Design, Scotland, Centre for Biomimetics, The University of Reading, Colbond Nonwovens, Cornelius Chemical, Outlast Technologies, Schoeller, Hallcrest Limited, DuPont, Hänsel Verbundtechnik, Cell International, Honeywill & Stein, Infenion, Bekintex, Sprint Metal, Bamberger Kaliko, Rotta, Mercia International Fragrances, CPL Aromas, Merck, Alveo AG, CHT Beitlich GmbH, Sericol and many other companies. Since October 2000 numerous discussions and correspondence with scientists and the textiles industry were conducted by telephone, through email or in person, and assistance regarding material samples was organised.

Biomedical research methods such as scanning electron microscopy and light microscope were employed during the early stages of the research to study the surface and cross-section characteristics of the skin. The results of the micrography imaging sessions are documented in a series of photographs, slides and digital data. Analysis of the images obtained informed the formation of patterns and surfaces for textile prints and other textile manipulations to mimic the skin's visual and structural characteristics.

Selections of suitable materials and technologies which might achieve the desired skin-like structural and tactile qualities in textiles were led by both the visual data retrieved from the micrography imaging and the survey on the bio-mechanical and sensual characteristics of skin. Relevant properties of the epidermis were selected for translation into my textiles practice for a concept of 2nd and 3rd skin, focusing on interactive and polysensual textile criteria, in addition to the regular functions anticipated. A series of practical experiments were executed in order to explore the various processes and issues as outlined in the scope set for technical experiments for interpretation of skin characteristics (see Chapter 01).

A range of technologies were employed, mainly focusing on industrial and new materials in synergy with more traditional textile materials and technologies. Electronic systems were incorporated in some of the work to support the interactivity. The samples were then assessed both from the visual and tactile point of view, as well as their integrated functionality.

As a result of these practical experiments, interactive and smart design solutions were modelled at a prototype stage for possible applications in intelligent interiors and clothing. These ideas were then exhibited for public scrutiny at the Fashion Space Gallery, London College of Fashion from October 27th until November 8th 2003. Additionally, individual textile installations were selected through a peer review process for the international exhibition 'Artists at Work: New Technology in Textile and Fibre Art' at the Textile Museum of Prato, Italy and for the exhibition 'Insane about the Membrane' at the gallery of the University of Brighton. Public review of the creative work was essential in order to analyse its reaction to new design work. One-to-one interviews with the visitors of exhibition were conducted in order to evaluate the public response (see Chapter 13).

Since that time I have expanded and modified traditional models of design and developed a transferable model of design for other researchers that are interested into this aspect. Formal model of research is discussed in Chapter 14 (14.1).

PART I

IDENTICATION OF SKIN

CHAPTER 03 ::

SKIN AS SOCIAL CANVAS

03. SKIN AS SOCIAL CANVAS

'We are the only creature on this planet which chooses and manipulates its own appearance.'[1] ***Ted Polhemus***

Skin has a dual function of protecting and representing the human body. Skin is not only a physical but also a psychological barrier between the private and the public, it represents a firm closing of the body and the self, simultaneously being a defining border from where the world starts. Located at the boundary between self and society, inner experience and outward projection, the skin is essential to the construction of identity. The individual in the body makes certain statements within the social context. There are different cultures and beliefs that separate human beings but, common to all, the body is the ground onto which all cultures inscribe significant meanings.

Culture is 'written on the body.' The social significance of the body and that of the skin, being the very site of the underlying body's representations, is enormous. Skin is a carrier of biological, aesthetic, psychological, historical, symbolical, religious, anthropological, mythological and political meanings. The skin issue is indeed multi-layered. However, this chapter will focus on skin as the site of wide range of physical alterations and enhancements. Some body modification practices will be followed in which the skin is literally used as some sort of canvas or fabric in order to emphasise, to improve, to change or to regain identity. As Robert Brain, author of 'The Decorated Body' says: 'Attention to the body is an attempt to put on a new skin, a cultural as opposed to a natural skin.'[2]

03.1 BODY AESTHETICS

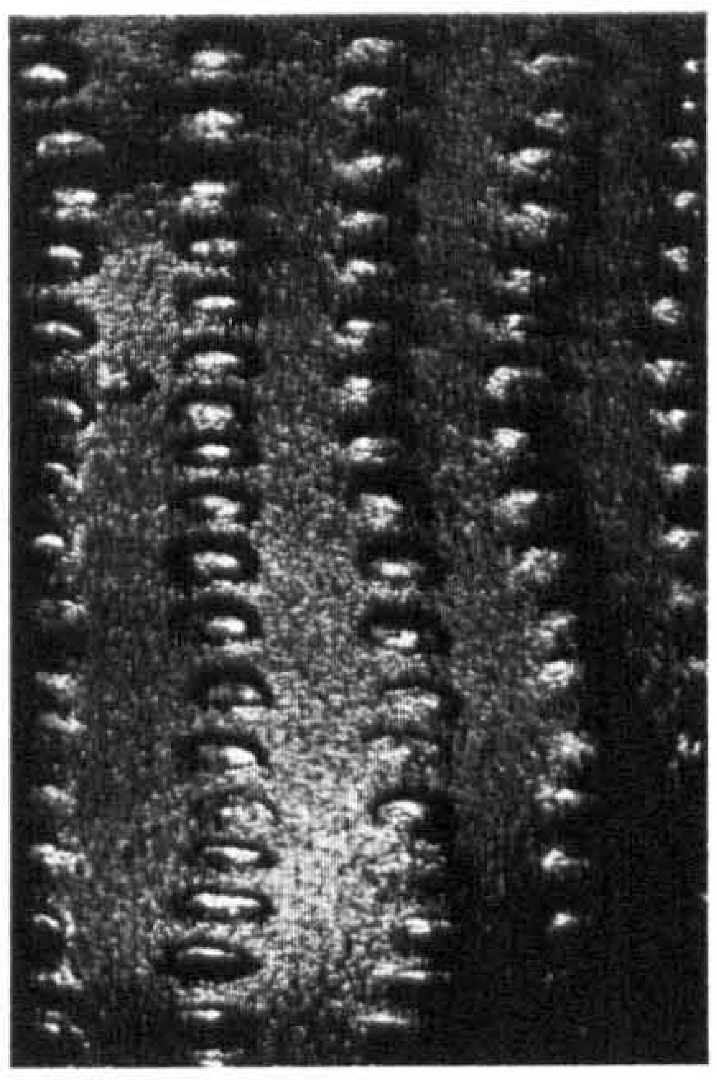
Different forms of body marking such as tattooing, painting, scarification, branding, and the use of henna or kohl have been observed and recorded in many regions of the world. The major modes and techniques of body art seem to be as ancient as the culture itself. Archaeologists and scientists provide hard evidence from a wide variety of cultures that have displayed and recorded forms of body modification for centuries. The body is a site of adornment, manipulation, and mutilation 'with roots reaching far back in the human record, at least 30,000 years.'[3] The earliest firm evidence for tattooing yet recovered comprises patterns of dots and lines on the mummy of a woman named Amuet who was a priestess of the goddess Hathor at Thebes during the XIth Dynasty of ancient Egypt, around 2200 B.C.[4] This discovery was only made possible because the body in question was ceremonially embalmed. Henry Rerguson and Lynn Procter in 'The Art of the Tattoo' affirm: '[...] the oldest tattoos so far discovered were those found on the frozen 5300-year-old body of a man that was unearthed in the Italian Alps, close to the border with Austria. This iceman [...] had 57 tattoos in various places on his body.'[5]

For many centuries a great variety of practices and techniques have been employed by both sexes to decorate, enhance, and modify the body. Scarification in Africa, bound feet in China, elongated ear lobes in Malaysia and large ear plugs in Ethiopia, Burmese women's stretched necks, New Guinea nasal septum piercing, Sara lip plates, Maori facial tattoos and deformed skulls. 'These are practices that have long fascinated the West where they have been viewed as exotic distortions of the body, as is suggested in the standard terminology of 'mutilation' and 'deformation' itself.'[6]

Today, with the more critical view of the West, these practices are seen as acceptable as opposed to being translated as strange manipulations. More likely these are references which help us identify how the body is always culturally constructed.[7] Similarly our Western venture into body transformations such as face-lifting and breast implants might also be seen as part of this long history. 'Primitive society was magic-ridden, therefore painting, tattooing and scarification must have a supernatural origin. On the other hand, Western society was rational, therefore the only explanation a Westerner could give for the need to decorate the body, particularly the face, was a sexual one,' suggests anthropologist Robert Brain.[8]

In modern society, body decoration is mostly a self-motivated expression of personal freedom and uniqueness, an individual or collective form of rebellion. In contrast to this there is a rather different understanding of these practices in tribal cultures, where the decorated body is a part of the social system within its given cultural context and the human body in its natural, unmodified state was often seen as incomplete. Here we have to do with deep traditions that mark the person as a member of the local group, or express religious beliefs and convictions. There are a variety of reasons for body decoration in so-called primitive societies: to indicate belonging to a tribe or totemic group, to mark one's age, social and material status, to deflect illness and evil, to gain entry into 'another' world after dying, to attain magical powers, to frighten enemies, to enhance sexual attractiveness and as a sign of mourning.

12 Nukahiwer tattoo designs, drawing, 1813.



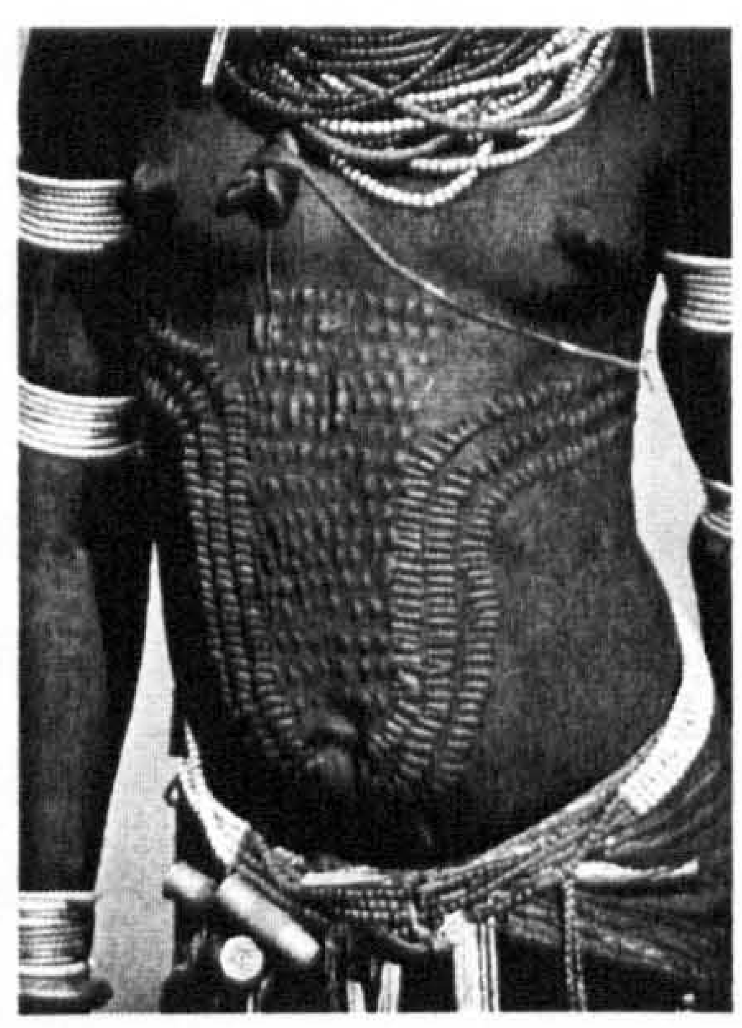
13

14

13 African scarification,
Bumi male body.

14 Hamar man (Ethiopia).

15 African scarification,
Karo man from Ethiopia.
The welts raised by body scarification not only are regarded as visual enhancement of beauty but also are valued for their tactile erotic quality.



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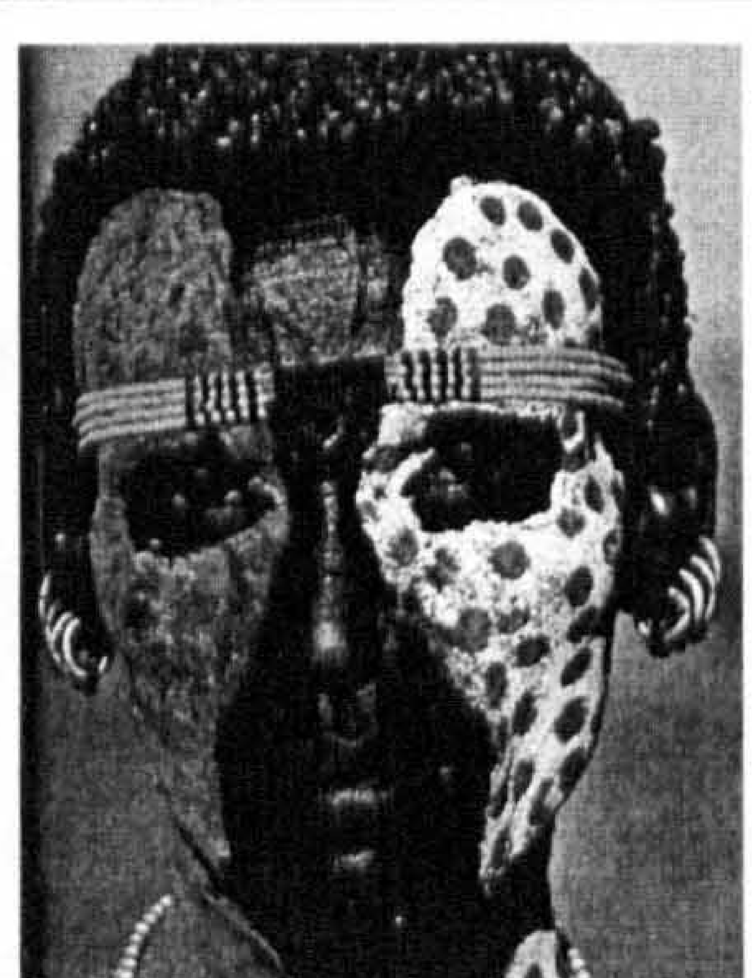


18

16 Maori facial tattoo *Moko*
(New Zealand).
Portrait of a New Zealand Man,
pen and wash portrait by
S. Parkinson, 1769.

17 Karo male body
painting (Ethiopia).

18 Karo man (Ethiopia).

03.2 BODY ORNAMENTATION

Body painting is classified as a non-invasive technique for temporal decoration. As opposed to invasive practices which leave permanent tracks in soft tissues (skin or flesh) such as tattooing, branding, scarification or structural changes to bones such as elongation of the skull or the neck or foot-binding, body painting does not involve any structural change or modification of the body or any of its parts.

The most elaborate forms of body ornamentation are generally seen on ceremonial and ritual occasions, involving serious preparation work and much expertise. Ceremonial decoration and body painting were often used in order to demonstrate personal belonging to the society or social group. However, '[t]he display of the body makes statements about the individual, too.'[9] In hierarchical societies the body surface is used as the area upon which men and women present their personal holdings of wealth and status. 'During an individual's lifetime there are also critical moments when the body is marked as a sign of transformation from one state to another. At birth, puberty, marriage and parenthood the body may be marked.'[10]

Tattooing is an invasive and permanent method of body decoration. It is widespread through the world, with examples occurring in most regions except in those regions of Africa where the people's skin is so dark that the introduction of pigment would have little effect. This was circumvented by the processes of scarification or cicatrization. These specific body art techniques were used as a medium for permanently marking the body surface by knife, introducing three-dimensional patterns of raised scar tissue instead of two-dimensional designs in colour. In whichever form, these practises serve to communicate people's social and personal values through the soft medium of skin and celebrate the symbolical body.

03.3 BODY CULT IN WESTERN SOCIETY

There are sequential Western ideals of the feminine body and masculine body, which hold huge sway over our lives. Currently, the contemporary ideology of fitness, the 'natural' and healthy look as a physical norm, are idealised in our society. Even if ignoring this standard, we are forced to deal with it continually, unconsciously or consciously comparing ourselves to other people and being compared by them ourselves. We are captives of fashion, our body is a constant work in process for cultural manipulations. The natural body, as a pure, unmodified surface, can only exist outside culture and its constructs, and this seems impossible.

We have arrived at a point where appearance and visual attraction is becoming all-pervasive. The modern beauty imperative is becoming an obsessive time- and money-consuming deal. Compared with complex social and religious reasoning for body decoration practices in primitive societies, modern make-up is generally used to make people's faces look more attractive, following the ideal of beauty and fashion. We fight fat, build muscles, wear hairpieces and undergo face-lifts in order to keep up the appearance of wealth, health and youth.

The Western notion of the 'natural' body is in fact a notion of a 'denaturalised' body because of all the artificial support needed to achieve this ideal. Of course, even the concept of denaturalisation embodies the idea of a belief in the existence of a natural body that should be reconstructed.

03.4 PRIMITIVE PRACTICES - ADAPTING THE STRANGE

With the geographical expansion of Europe during the 15th to 18th centuries, the customs of tribal peoples became more widely known. Once seen as a bizarre ritual reserved for Navy and military men, tattooing in the 20th century has developed into a widely appreciated body art form in the West. Modern electric needles have made the process of tattooing quicker and less painful. Some people have large areas tattooed but generally, the chest and arms remain the most common parts for this kind of body decoration. According to Rubin, motivations for getting a tattoo might be various. He has classified them in five categories: symbolisation of an emotional relationship, participation in a group, representation of key interests, representation of self-identity and decorative/aesthetic statement.[11] For example, in the 50's and 60's, popular motifs included the names of loved ones, often with hearts and flowers. Members of breakaway groups like to choose words or symbols of rebellion, such as the skull and crossbones. Probably the most clichéd tattoo in Western society is a heart with 'Mum.'

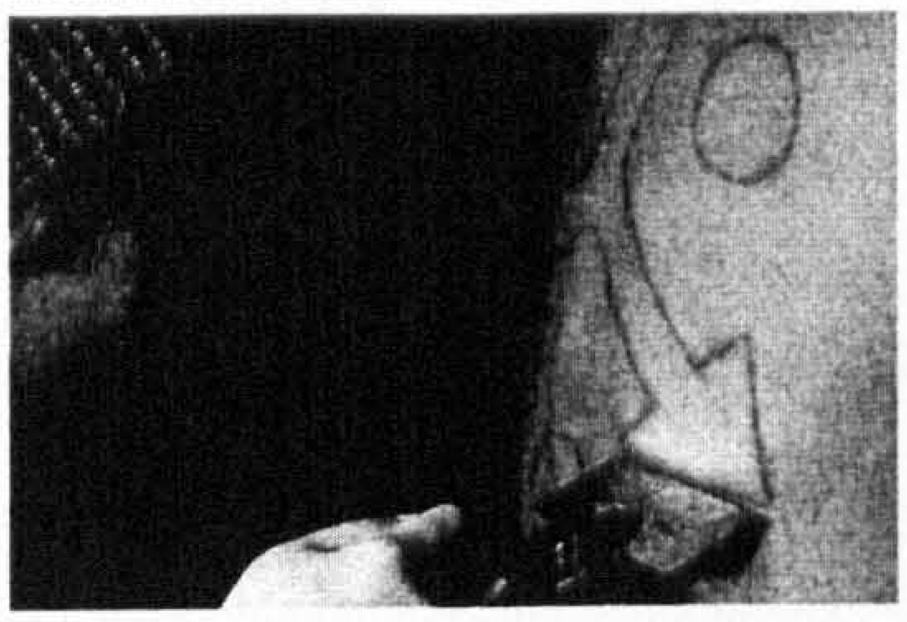
Now, many tattoo styles are practised concurrently in our society such as Japanese, Tribal, Native American, Celtic (Fig. 19) as well as numerous influences from Flora and Fauna, Abstract Art, Cartoons, Myths and Legends. Motifs embodying representations of the fantasy worlds or images of death and horror are also quite common (Fig. 21). Yet another tattooing genre can be found amongst prisoners who engrave certain signs onto the skin which serve as a code to recognise each other. In a way they are following the 'prison tribe' rules.

19 Brian (Tribal style tattoo by Alex Binnie, England).

20 George Davies, 80ys. (All-over tattooed by H. Potter, England).

21 Mike Bozz (A lively skull tattoo by Filip Leu, Switzerland).

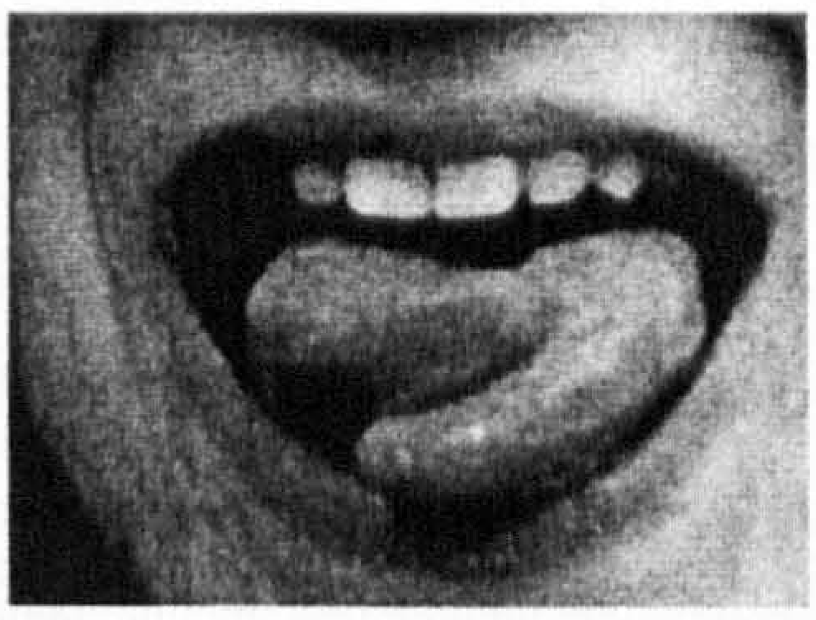
19, 20, 21



'Boodmod' practices:

22 Branding.

23 Laser-cut tongue.



22, 23

24 Ageing is a biological process that cannot yet be effectively stopped.

The marked skin manifests a literal declaration of our emotional roots. Apart from tattoos and piercing, many other primitive practices concerning body modifications have surfaced over the last 15 years in urban societies (Fig. 22). The German magazine 'Spiegel' (13/2000)[12] has an article about a 29 year old sociologist from New York undergoing laser-cut procedure to separate her tongue into two independent parts (Fig. 23). Obviously both organ parts can be separately directed by her brain, since the woman is able to hold simple objects with her tongue parts, like a cigarette for instance. Additionally, she underwent scarification by cutting away finger-width skin pieces in order to create the desired pattern of wounds.

Control over the pain is more important for 'Bodmod' fans than the eventual sexual excitement. These types of body rituals are a reason for many disputes among physicians and psychologists: are those self-tormentors mentally ill or do these procedures have a psychotherapeutic impact? Forensic biologist Mark Benecke[13] comments that for many 'Bodmod' practitioners the sense of the body has disappeared and the remaining wounds are an attempt to fill this emptiness. Most 'Bodmod' practitioners are single and, therefore, eventually the painful procedures can be viewed as a way to gain a feeling of affiliation to the group.

Extreme stretching and deformations of soft-tissues are still practised among many cultures in Africa. The patterns of their wounds represent their membership to the tribe, social status and their changing life circles. A part of the 'Bodmod' scene people also understand themselves as 'modern primitives' in search of their own roots.

03.5 (RE)MAKING BODY FOR HAPPINESS - METAMORPHOSIS AND EMOTIONS

Tolstoy wrote in 'Childhood,' '[N]othing has so marked an influence on the directions of a man's mind as his appearance itself, and not his appearance itself, so much as his conviction that it is attractive or unattractive.'[14]

Manipulation of the cosmetic character can be seen as liberation for many unlucky people who feel 'incomplete.' A new or modified skin is a new or modified personality. In many cultures there are myths of old and ugly people removing their skins and becoming young, beautiful and happy, the last one being the most important aspect. Cosmetics, therefore, may have a magical or therapeutic effect on morale and self-confidence.

Cosmetics are also strongly connected with the basic human need for self-identification in a large group of individuals. As long as this remains a pertinent issue, people will continue to manipulate their appearance. 'A sane perception of self is closely linked with a sane perception of the body. As we paint our eyes, trim our body hair, put on our ties, belts and ribbons, we are creating a self-portrait of ourselves.'[15] In Western society we have only restricted the amount of skin available to be used as a cosmetic language. Often our code, dominated by fashion, is based on our 'second skin,' our clothes.

In the 80's the adornment of the 'perfect' body and 'perfect' skin emerged as an important tendency. Transformations of the body surface became much more radical through the alteration of its physical characteristics. Cosmetic surgery, fitness studios for women and body-building for men became widespread. Woman's growing self-confidence was emphasised through her fashion statement.

According to Dev Basra: 'Aesthetic plastic surgery is a union of aesthetics and medicine. Aesthetics can be defined as the philosophy of taste, and the degree of appreciation is the measure of aesthetics.'[16] In 'Making the Body Beautiful', an extensive study of world history and cultural theory of aesthetic surgery by Sander Gilman is given a clearer definition on this subject: 'The name aesthetic surgery seems to be a label for those procedures which society at any given time sees as unnecessary, as nonmedical, as a sign of vanity. 'Aesthetic' surgery is the opposite of 'reconstructive' surgery, which is understood as restoring function.'[17]

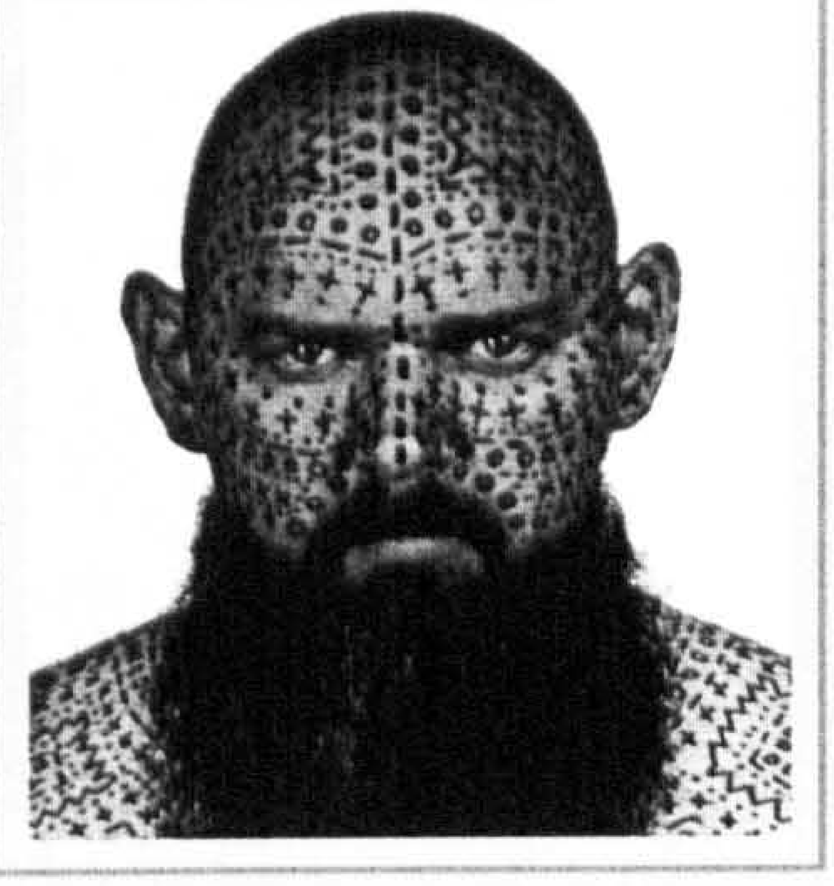
To quote Sander Gilman again: 'In a world in which we are judged by how we appear, the belief that we can change our appearance is liberating. We are what we seem to be and we seem to be what we are! All of us harbor internal norms of appearance by which we decide whom to trust, like, love, or fear. We act as if these internal norms are both fixed and accurate. But we constantly redraw these visual maps as we negotiate the world with all of its complexities. And as we see the world, the world is also seeing us, judging us by our appearance. To become someone else or to become a better version of ourselves in the eyes of the world is something that we all want.'[18] People believe that by transforming the exteriors of their physical bodies they can change their lives and cosmetic surgery is increasingly being considered by health services as necessary psychiatric and psychotherapeutic treatment.

Obsession or perfectionism?

25 Michael Jackson.

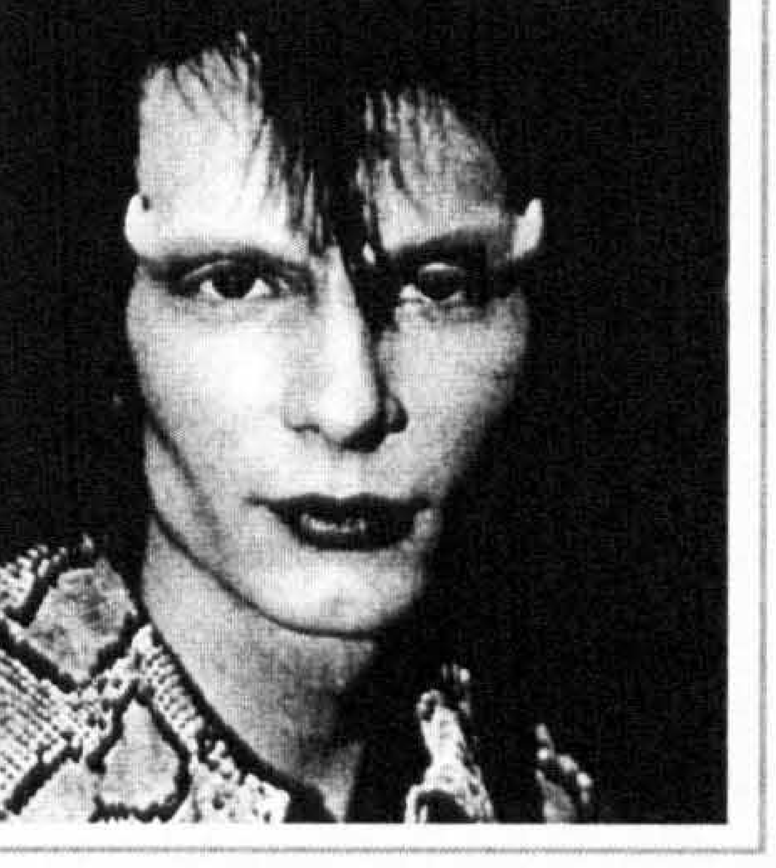
26 Cher.

25, 26



27 *Starship Party* portrait of the Belgian fashion designer Walter van Beirendonck. The extension of the symmetrical indigo pattern from the torso to the face, makes a powerful design impact.

28 In the Winter 1998/99 collection 'Believe', Walter van Beirendonck explored the world of plastic surgery and changing ideals of beauty. The collection is inspired by the French performance artist Orlan.



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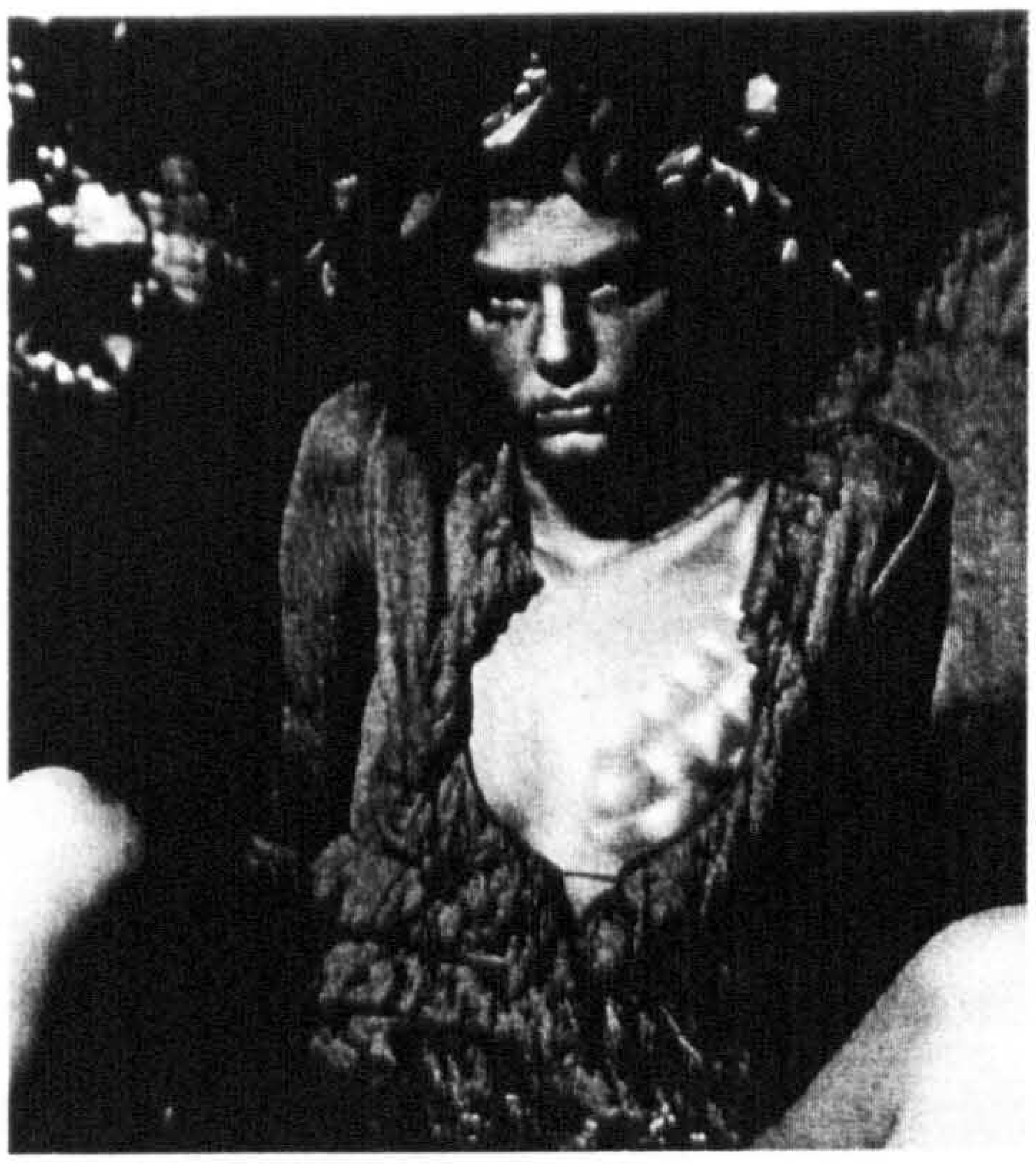

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29 SKINTHETIC:Chanel, 2001
Digital rendering.
Designed by Carla Murray and Peter Allen, KnoWear. Skinthetic is a series of design proposals for 'implant and explant' products that might in the future be used to extend consumer branding to the human body.

30 Das Schamgefuehl, 2001
Designer: Tina Gillmann
The ageing of skin begins with little deformities before it becomes a condition. Tina Gillmann uses scars, furuncles and warts as an aesthetic language in her work.

31

32

31 Issey Miyake, collection dedicated to the memory of J. Hendrix and J. Joplin, 1970.

32 Issey Miyake. The make up of the model is inspired by tribal body ornamentation practices.

33 South American body ornamentation design.

34 Design by Issey Miyake is inspired by South American body ornamentation, 1990's.

33

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03.6 DESIGNED SECOND SKIN

Similarly to the practices of cosmetologists and aesthetic surgeons, the idea of changed and constructed looks (identities) of people is one of the main drives in fashion, sustained by the never-ending human desire to improve ones appearance. Supported by high-performance fabrics, designers are producing garments that can modify and enhance our self-presentation.

Fashion designers exploit the iconic fantasy of perfect proportions and technologically advanced fabrics such as elastic Lucra® and Dorlastan® for instance, allowing them to create garments that highlight the anatomy of our bodies by intimately tracing its shapes. Literally our clothes are becoming another layer of our biological skin, additionally capable of offering the comforts of integrated skin-like bio-active and intelligent textile systems (thermo-regulating, antibacterial, respiratory, etc.). To address this issue, examples are described in Chapter 05 – Textiles – the Engineered 2nd and 3rd Skin and in other places within my thesis. However, in this current part I would like to emphasise some of the leading fashion designers preoccupation with the aesthetics of the skin and its semiotics per se referencing tribal and contemporary body modification practices. Also examples of art practices using the metaphor of skin will be discussed.

03.6.1 SKIN METAPHOR IN FASHION PRACTICES

The metaphor of skin is perhaps most often used in fashion, referring to clothes as our second or cultural skin. However, this subject is interpreted variously by different designers. A Belgian fashion designer Walter Van Beirendonck's[19] (Fig. 27) work considers our society's sensibilities dealing with the body, skin and fashion. In the collection *Believe*, Autumn/Winter 1998/99, his creation was inspired by French performance artist Orlan and her concept of creative body hybridisation as a life and art form (see 06.3.1). For the fashion show *Believe*, Walter designed artificial lumps, that were made and put on the models' faces by prosthetic make-up artist Geoff Portass (Fig. 28). 'Van Beirendonck used this collection to explore the field of pre-surgical and prosthetic make-up.'[20] Presenting the idea of aesthetic metamorphosis of the human body surface – prosthetic as beauty aesthetic, he let the models go on the catwalk wearing extensions of the body and face, avoiding conventional make-up.

In an interview for Italian Virus magazine, Van Beirendonck, when asked about cosmetic surgery in which people add artificial parts to their bodies to change their genetic complexes says: 'All the recent experiments such as cloning or biological engineering are fascinating but at the same time also scary. I'm sure that FUTURE life (and fashion) will be directly influenced by the evolution of these experiments.' He continues: 'Plastic surgery is one of the main inspirations in my last collection. Used in a creative way it can be interesting for future beauty.'[21]

In 1970, Issey Miyake created a collection dedicated to the memory of Jimi Hendrix and Janis Joplin, both recently deceased (Fig. 31). The faces of the rock-stars were incorporated into printed designs which were based on tattoos, dominating his collection. These were Miyake's first ever tattoo garments. Originally, in Japan, tattoo patterns were closely associated with downtown yakuza gangsters. The East-West motif was worn close to the body, underlining the idea of 'another skin.' In the same year Miyake Design Studio introduced Miyake's concept of clothing as a 'second skin' to the world.

Miyake had followed the idea of the 'second skin' all through his creativity. In the beginning of the 90's, the Japanese fashion designer worked on another collection exploring South American body ornamentation practices - its colour, pattern, and vitality. The three-dimensional patterns of scarification practices from Africa served as an inspiration for the creator.

Another designer Martin Margiela has also been exploring the idea of a tattooed body in his creative practice. In his Autumn/Winter 1994/95 collection he showed garments that are exact reproductions of pieces from various periods and are printed with details of their origin and epoch. One of them was a transparent top with an exact 1: 1 male tattoo pattern from Tahiti worn by a female model as if it was the 'real' skin of the owner (Fig. 37).

03.6.2 SKIN AS METAPHOR IN ART

The Italian based artist Robert Gligorov, working preferably with photographic images is used to astonish and surprise his audience. For this end he often uses the metaphor of skin and references to the body to provoke extreme sensations, associations and shock. His work *Waiting*, consisting of two photographs taken of Gligorov dressed in a jacket made of cow's flesh, one month apart (Fig. 43, 44).

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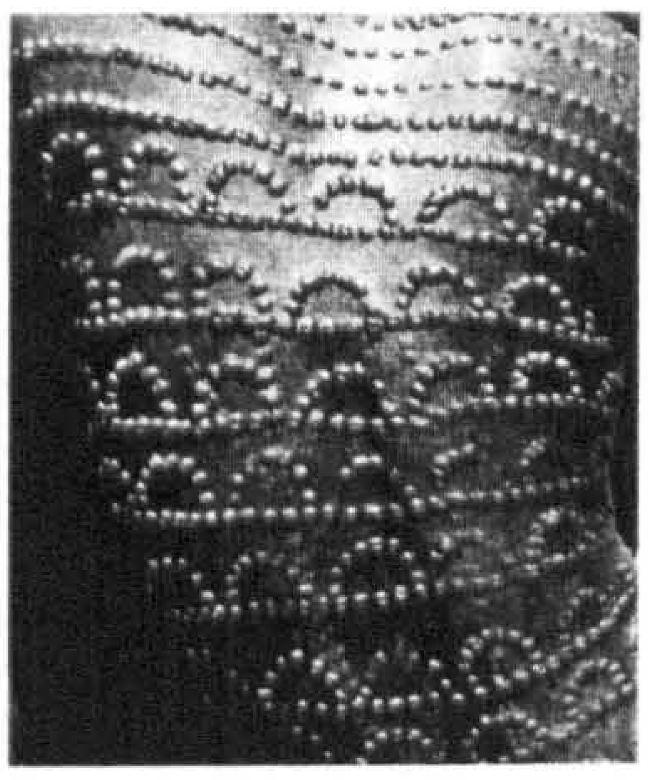

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35 Out-fit by Issey Miyake, inspired by African scarification patterns.

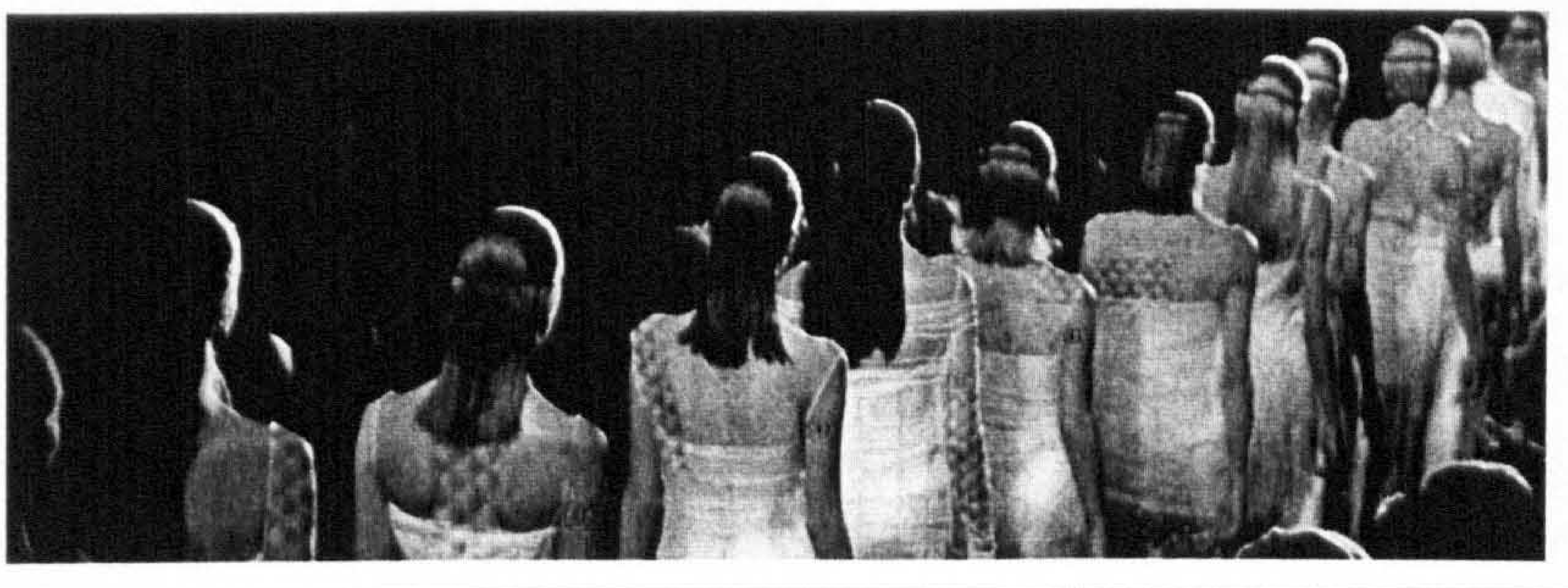
36 African scarification pattern.

37 1994 collection by Martin Margiela. Top inspired by Tahiti male tattoo design.

38 Tahiti male tattoo.

39 SKINTHETIC: Chanel, 2001

Digital rendering. Designed by Carla Murray and Peter Allen, KnoWear, Cataumet, Massachusetts. A quilted pattern derived from Chanel's brand identity is applied to the human torso. The skin of the garment becomes continuous with the skin of the body.



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40, 41 Fall collection 2001 by Yoshiki Hishinuma. In some of his pieces, a sheet of vinyl is laminated to the translucent layers beneath; the vinyl is allowed to crack, exposing the delicate flesh below the broken skin. These pieces explore the beauty and complexity of wrinkles, tears and imperfections.

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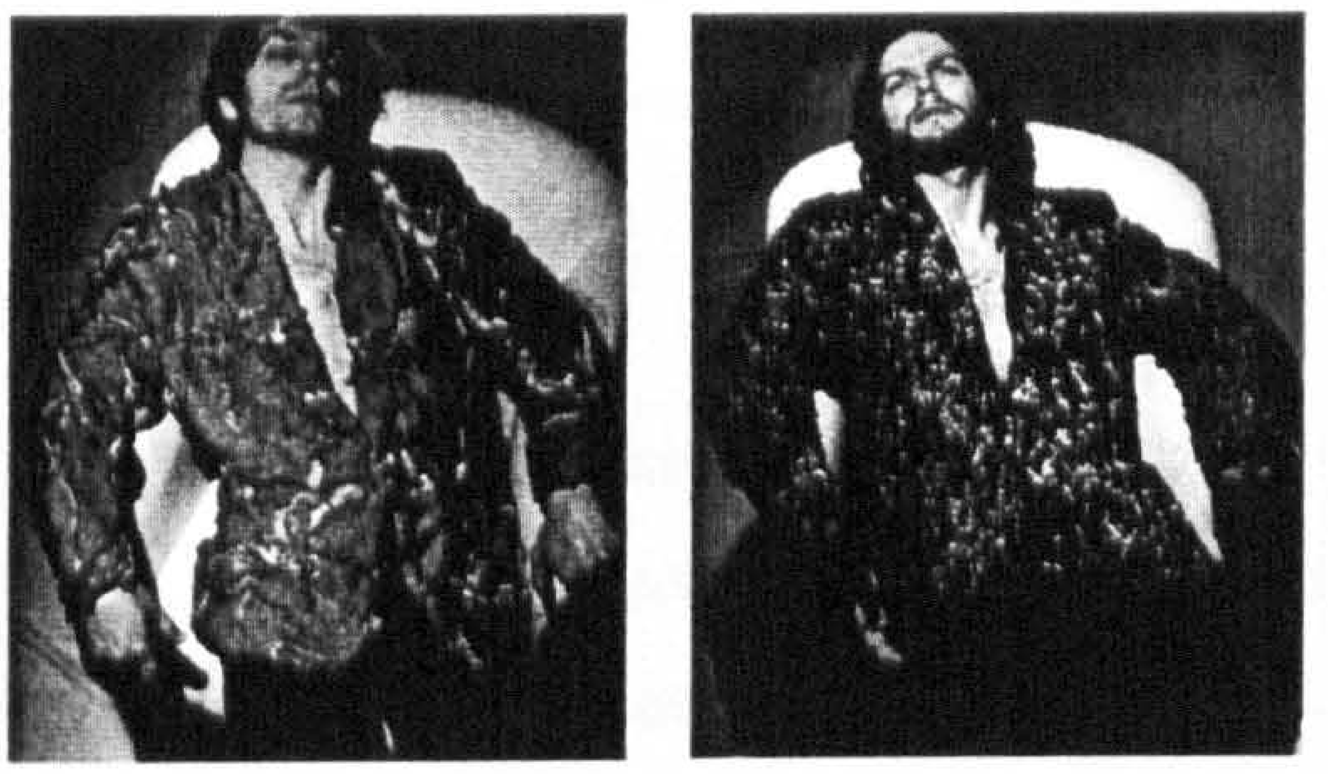

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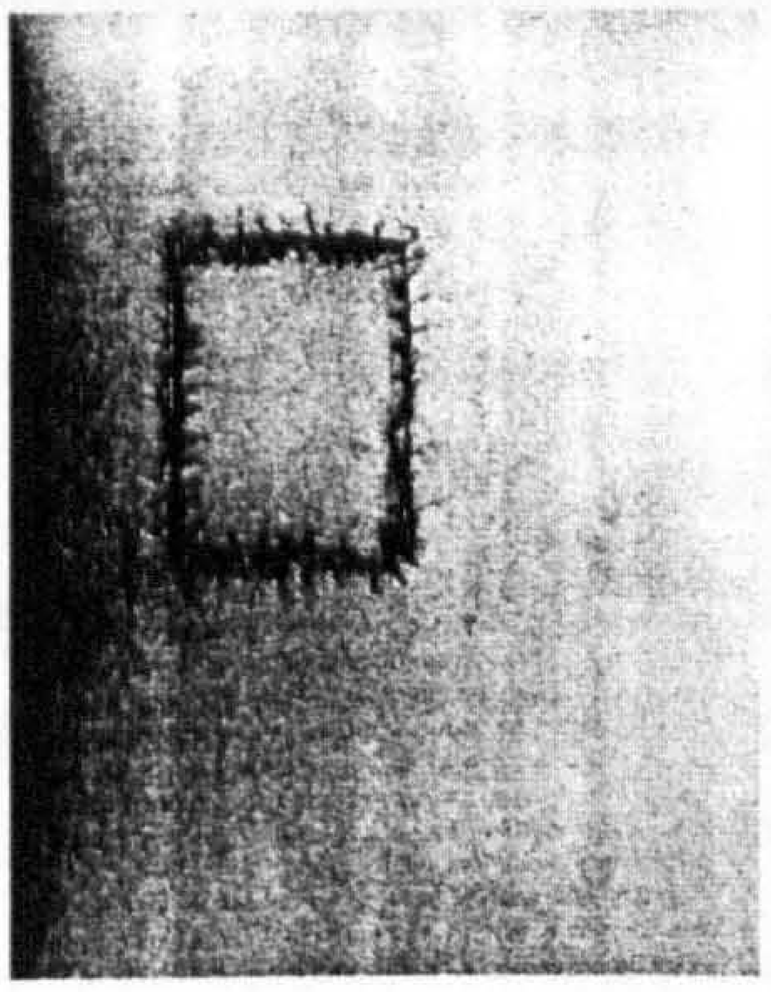

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42 Huma Furrier, 2000
Peach nipple handbags and shoes, silicone and leather. Artist: Nicola Costantino.

43, 44 Waiting by artist Robert Gligorov.
Cibachrome on aluminium, 1997.

45 The Immortal Tailor, 1995-1997 Garments, digital print on fabric by artist Alba D'Urbano.

46 Shoes, 1997 Artist: Robert Gligorov
Sculpture, mixed media.

47 Untitled, 2000
Artist Sarah Lovitt shapes wax into a skin-like surface.

'*Waiting* shows death at work. It reveals itself with all the obstructing anguish, not of an idea but of a physical process,' writes art critic Cristiana Perrella. 'The jacket has an irritating solidity, a greasy and viscous consistency that we seem almost able to feel on our skin.'[22]

In another work by Robert Gligorov 'designer' shoes are depicted in a computer manipulated photograph *Shoes* (Fig. 46). *Shoes*, being a consumer object are made of 'real' human skin instead of that of animals. This direct association, illustrated in such a naturalistic manner, literally provokes 'goose skin' in the viewer.

A similar idea has been communicated by designer Nicola Costantino who created *Human Furrier* in 2000, which are peach nipple handbags and shoes made from silicone and leather (Fig 42). These conceptual art pieces comment on the meat and leather industries. 'In the surrealist tradition, these hand bags and shoes are imprinted with tiny images of human nipples and anuses. Recalling the look of ostrich leather, the effect is at once decorative and alarming.'[23]

Sarah Lovitt's framed skin-like wall relieves *Untitled* are concerned with the incarnation of pain and metamorphosis (Fig. 47). The American artist's series of smoothly moulded cream-coloured wax surfaces with surgical stitches that are closing up a small square wound, speak of physical suffering using a minimal vocabulary.[24]

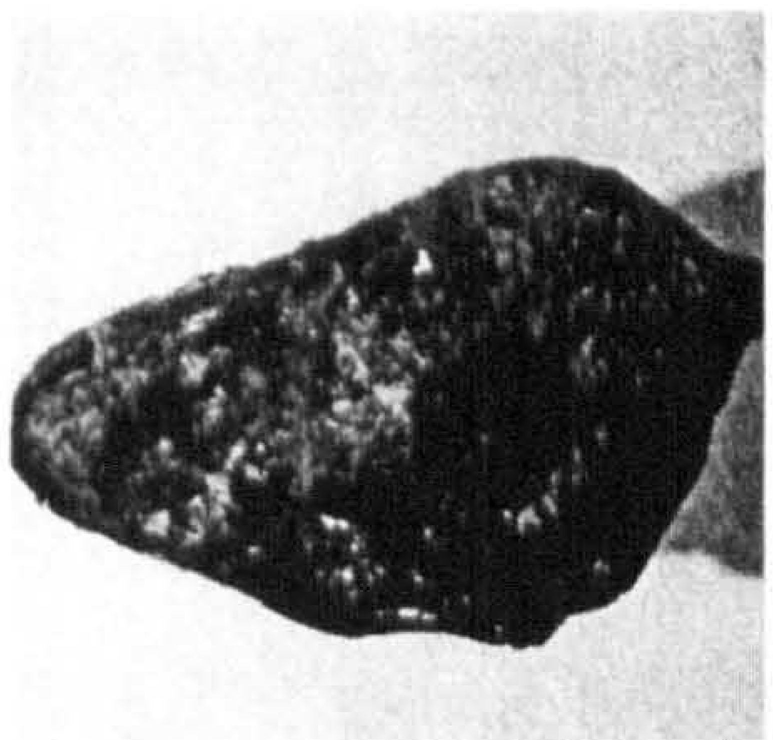
Artist Alba D'Urbano, using digital photographic media in combination with CAD fashion design methods, has created a series of garments that cover the body with images of itself. This collection called *The Immortal Tailor* is produced using inkjet printing on fabric and due to the use of digital technologies, the body ultimately becomes an abstract data landscape (Fig. 45). 'The result is fragmented, contradictory visual condition that oscillates between naked and clothed, flatness and dimensionality.'[25]

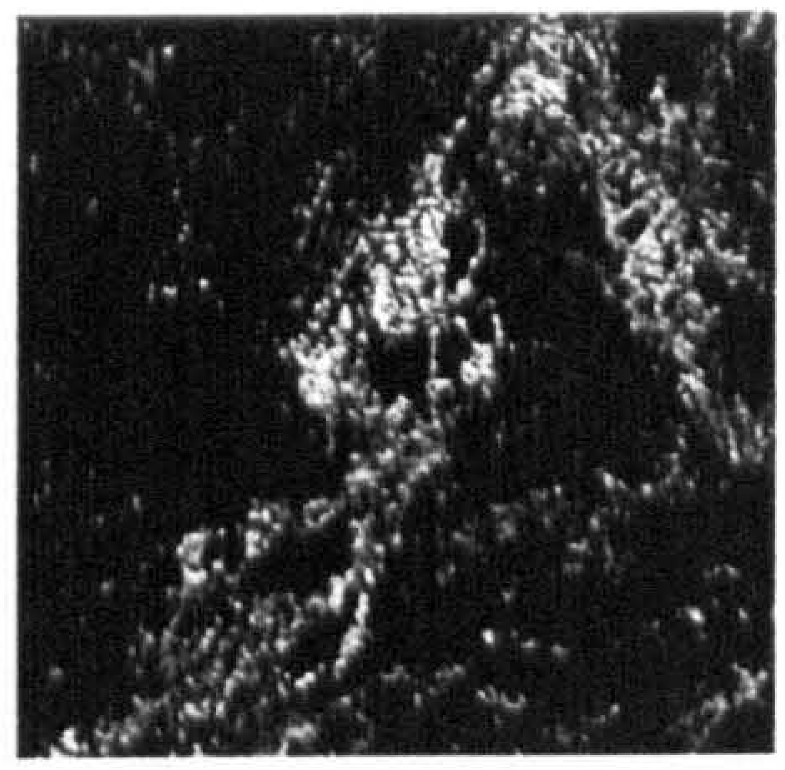
Another artist Caroline Broadhead is well known for her use of garments to define the absent body – dresses are hung in the space or spray out across the floor in a flow of soft fabric. Some of her work features just a single thread with its accompanying shadow on a wall in order to reveal the contours of a body. These garments or skins, which actually refer to our emotional states, live their own lives - sometimes they reassemble alienated husks, sometimes they become astonishingly alive.

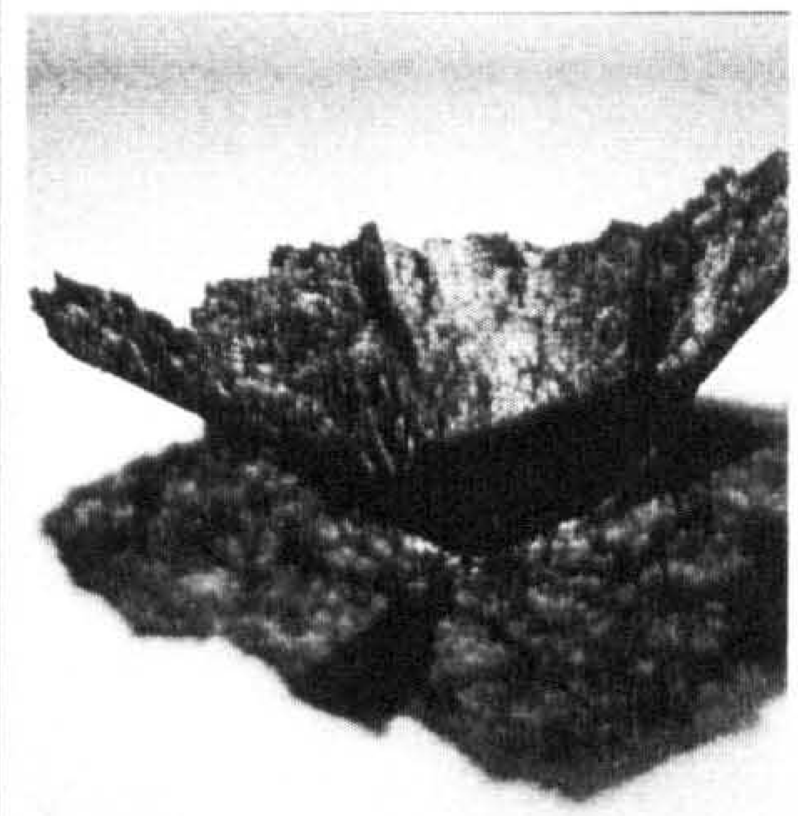
While many artists tackle the body and its surface in their hyper-natural form – from painter Lucian Freud's (Fig. 57) giant Rubens-type women with fleshy skin to Margi Geerlink's (Fig. 55, 56) living skin garments – others, like Caroline Broadhead and

Francess Geesin, refer to the body in more metaphoric terms. Weather by fragmenting it, concealing it, or defining it by its absence, with a lyrical approach of an artist the body and the epidermis is undergoing a metamorphosis changing from a physical state to a psychological state in powerful ways.

Textile designer and artist Frances Geesin, works in an emotional territory exploring the responsive qualities of thermoplastic fibres and fabrics. She creates delicate vessels, membranes and skins involving an electroplating process to harden and define the boundaries of the objects (Fig. 48-50). Frances Geesin comments on her practice: 'For my work I seek out or make textile materials which respond to heat and steam, that shrink around a form, creating a mask or second skin. As the heat plays on the fabric it distorts and distresses, fractured holes reveal wrapped space. The heat gun becomes my drawing tool as I seek out structure and texture. The impression is of fragility yet the plastic material has a strength, which is enhanced through the electroplating or metalising process. The addition of patination enhances one's perception of mood and time, suggesting a personal narrative.'[26]







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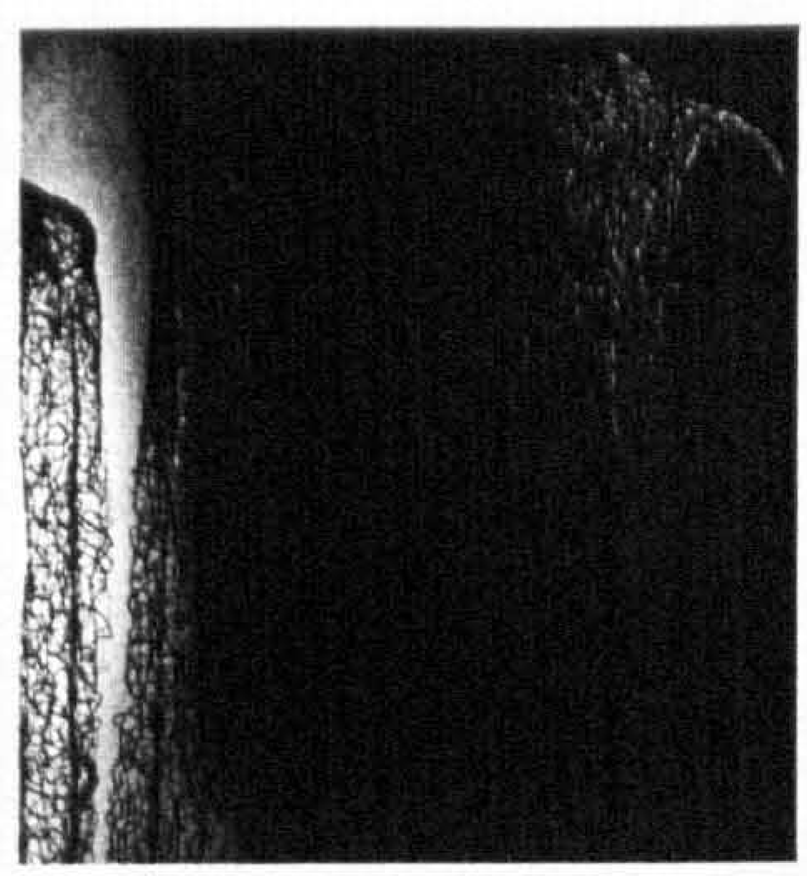
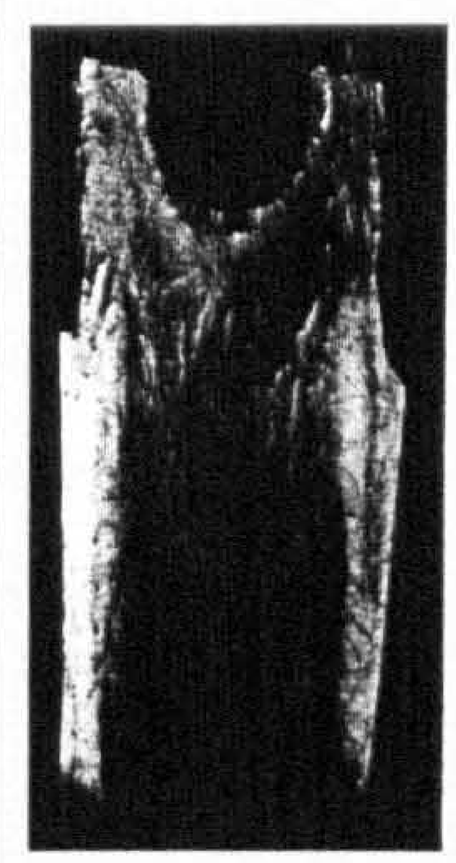
48 *Vessel* by Frances Geesin. Thermoplastic nonwovens and electroplating process. Author's technique.

49 *Vessel* by Frances Geesin, detail.

50 *Vessel* by Frances Geesin. Thermoplastic nonwovens and electroplating process. Author's technique.

51 *Shawls*, 2000
Artist: Almyra Bartkeviciute from Lithuania. Glue, thread, author's technique.





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52 *Untitled*, 2000
Artist: Mirja Puppel from Germany. Latex, nature materials, author's technique.

53 *Recycled Shells*
Artist: Anda Klancic from Slovenia. Author's technique.

54 *Hauttausch* (Exchange of Skin), 2001
Artists: Birgit Jobst and Diego Vasquez. Digitally manipulated photograph.

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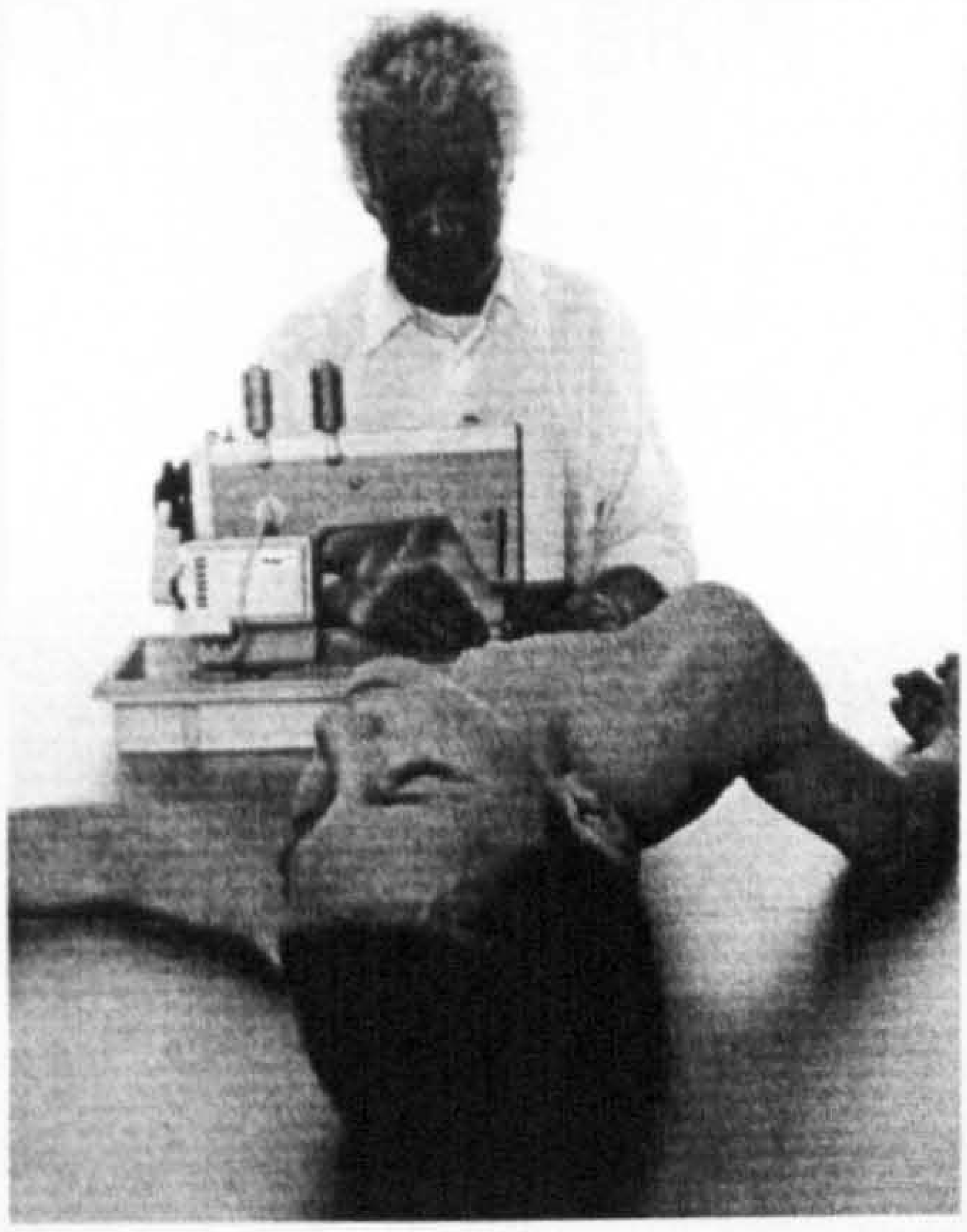
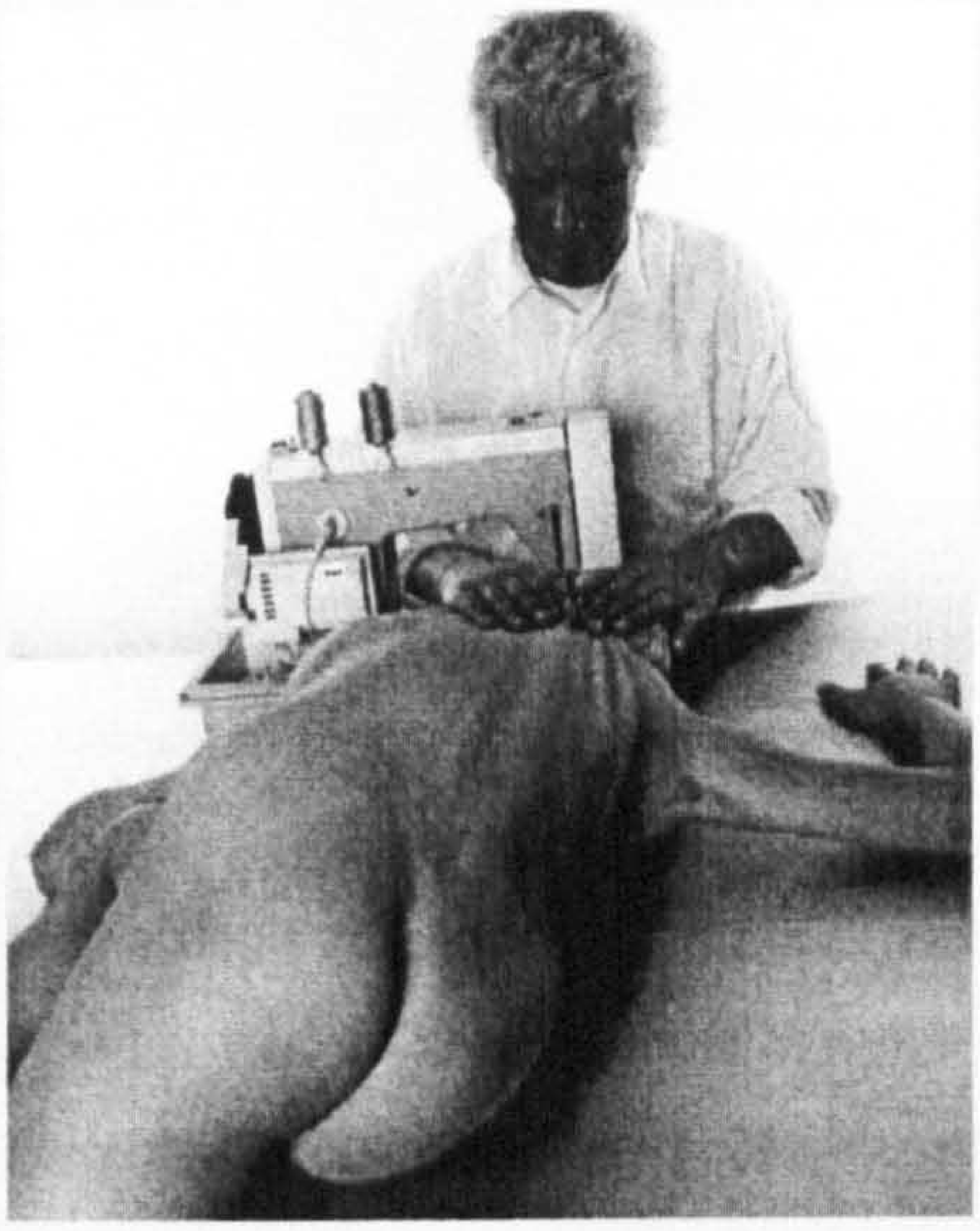
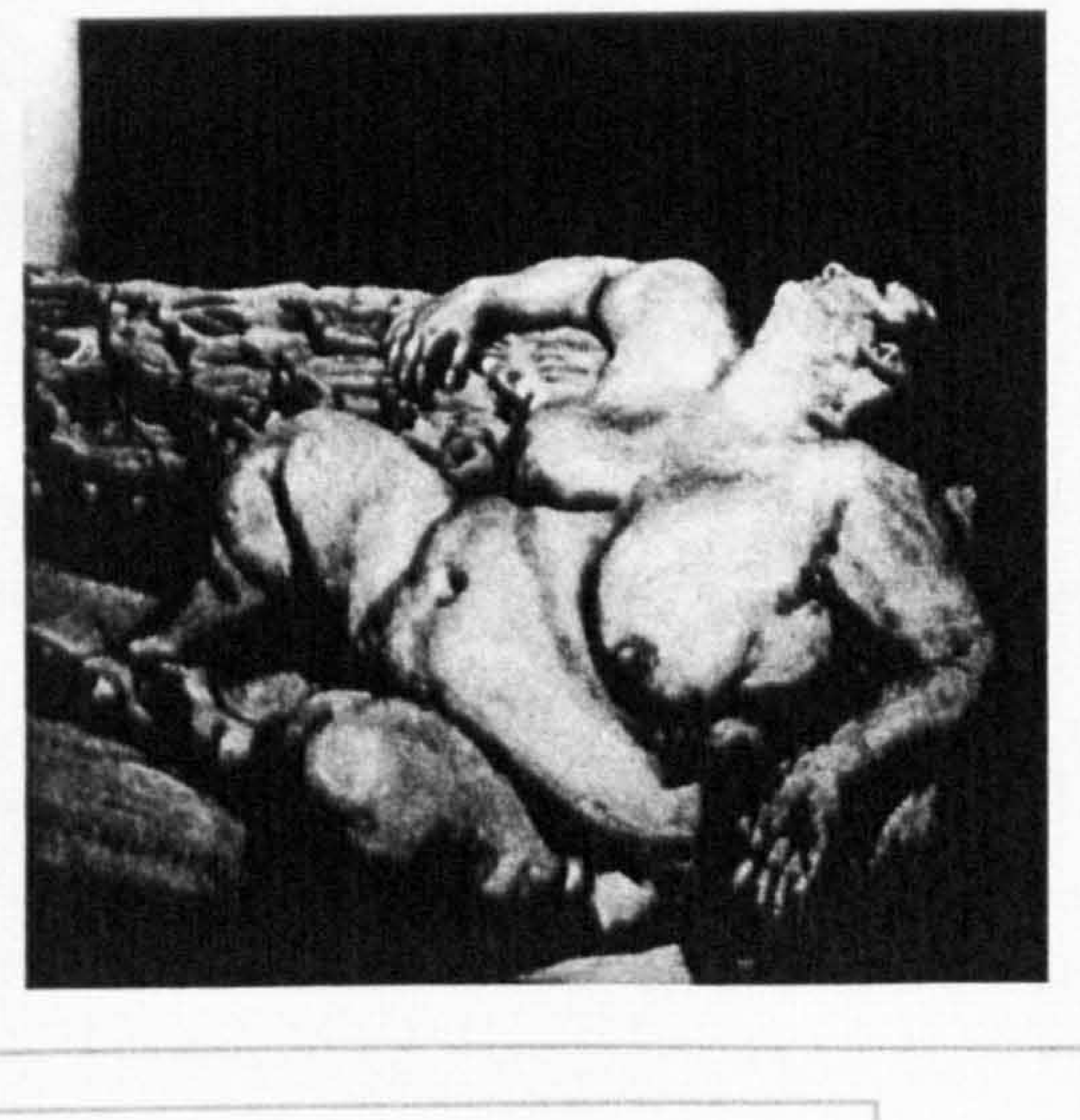


55 GEPETTO 1, 1999
Photograph by Margi Geerlinks.



56 GEPETTO 2, 1999
Photograph by Margi Geerlinks.



57 Benefits Supervisor Resting, 1994
Artist: Lucian Freud.

CHAPTER 04 ::

BIOLOGICAL SKIN

04 BIOLOGICAL SKIN

'Just a square centimetre of human skin contains 7.5 million cells, 245 sweat glands, 35 sebaceous glands, 25 hairs, 2.5 meters of blood vessels, 7500 sense cells, and 8 million microscopic living organisms.'[1] ***Marc McCutcheon***

After the discussion on semiotics of skin in different cultural and personal contexts, as well as artists and designers creative responses to the multiple skin issues I would like to approach my main research interest that has directly influenced my textiles practice - the biological skin.

Our skin (cutis) is an engineering masterpiece of nature. Being a complex and extensive biological organism, it has to perform various, vitally important physiological functions, including acting as an 'information-processing system: receiving information from the environment and transmitting it back.' [2] In this Chapter the structure, functions and various conditions of the skin will be discussed.

04.1 THE STRUCTURE OF THE SKIN

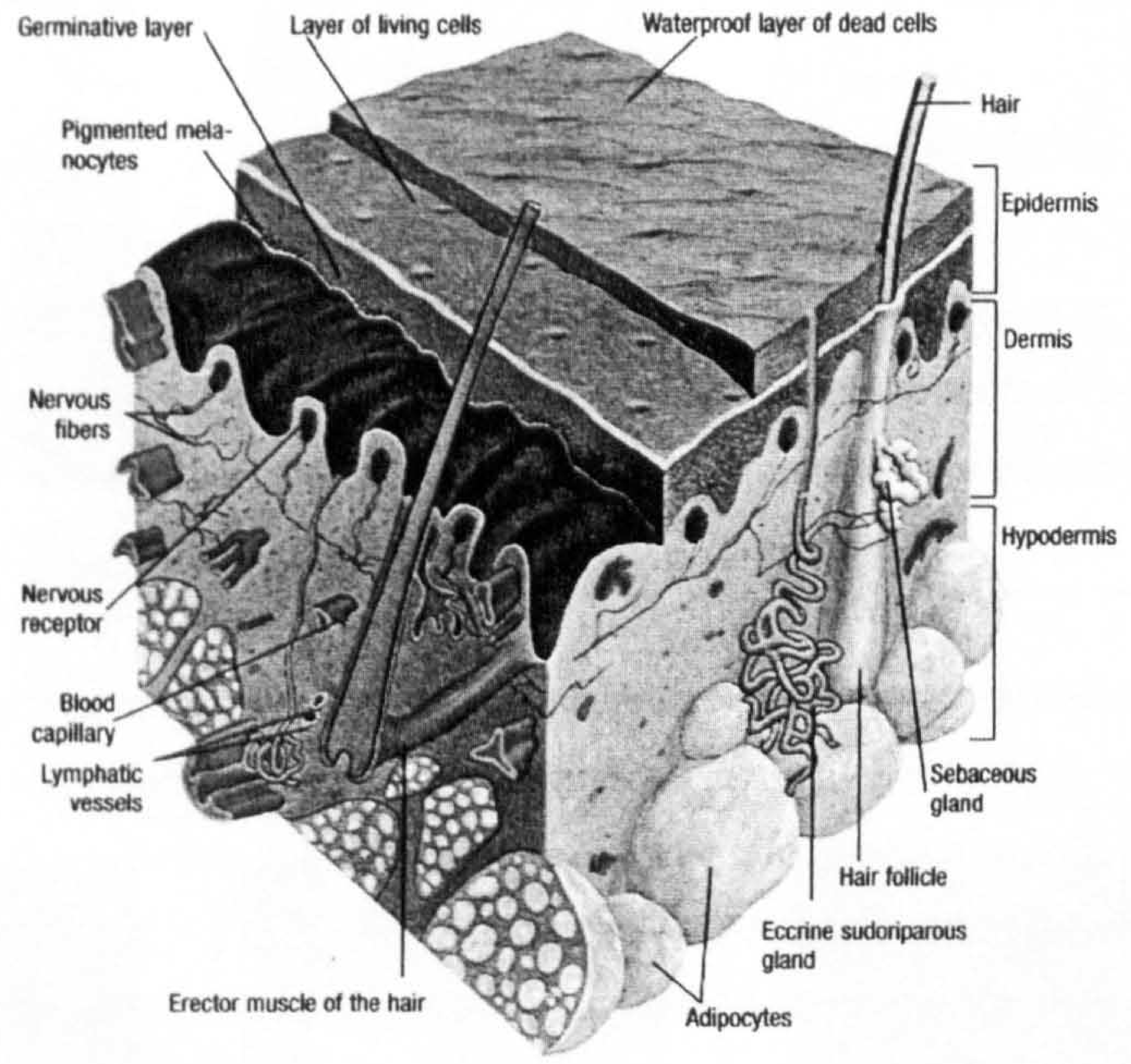
The skin can be divided into three main layers: epidermis, dermis (cutis vera) and subcutis, also called hypodermis (Fig 58,59). The epidermis mainly serves as a major protective barrier consisting of a waterproof layer of flattened dead cells (stratum corneum) and is derived from ectoderm cells.

The dermis, which is closely connected to the epidermis, lies directly below it and is composed of collagen and elastin. Horizontally running bundles of mechanically strong collagen fibres make up 70% of the dermis and give structural toughness and strength. Elastin fibres are weaker but much more flexible. They are found deeper and are loosely arranged in all directions giving elasticity to the skin.[3] Due to these structural arrangements, skin is elastic and can be stretched and compressed within limits; good frictional properties support locomotion and manipulation of the body.

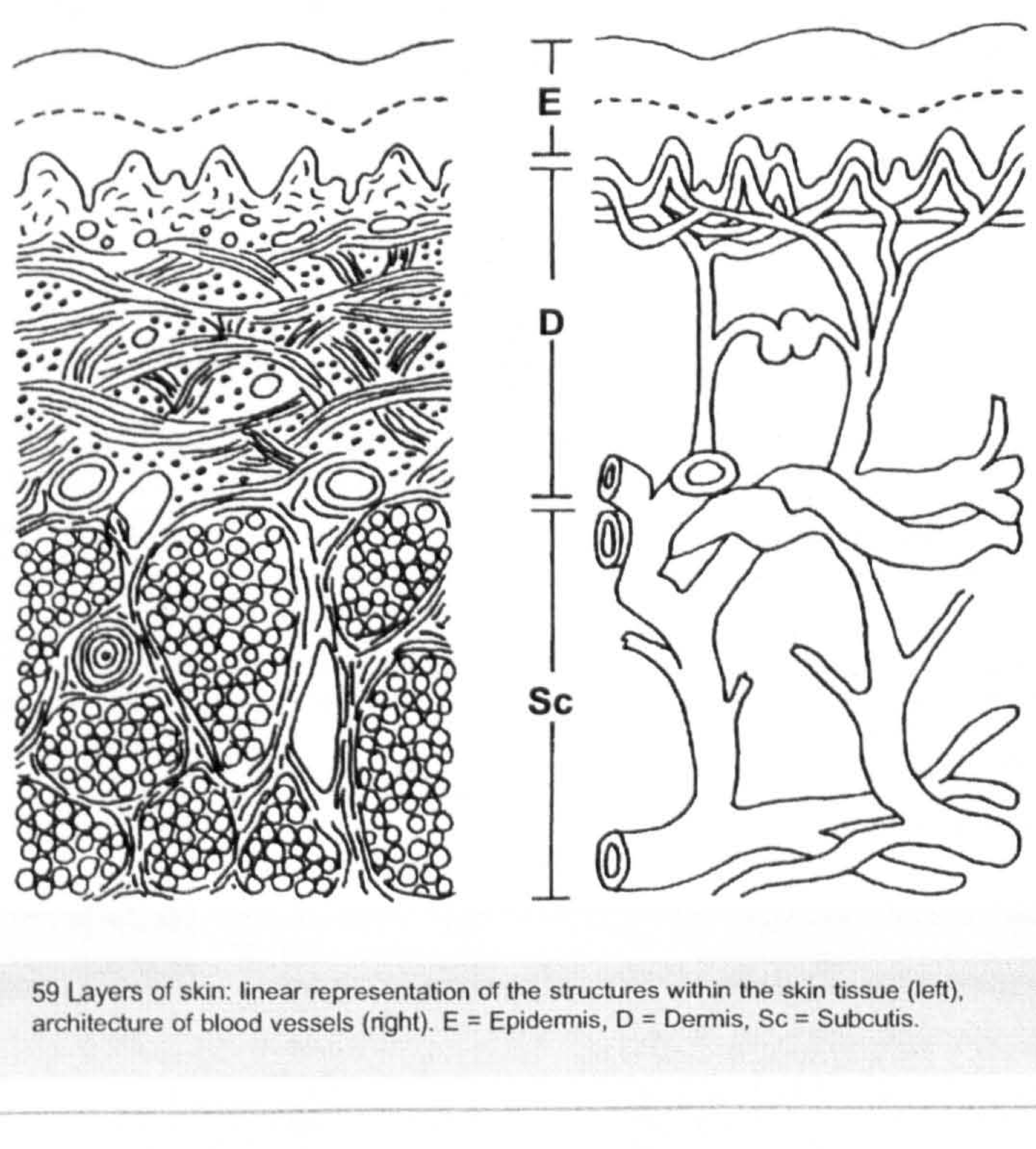
The dermis is rich in hair follicles, sweat and sebaceous glands, which are epidermal derivatives extending down into the dermis. There are also blood vessels, nerves, and many nerve endings.[4] The nerve endings in our skin enable us to experience tactile phenomena and to sense pain, temperature and pressure. The sweat glands help regulate the temperature of our body, cooling the skin by sweating. Oil or sebaceous glands produce oil to keep the skin elastic and youthful but hair follicles help to insulate the body. When we are cold our hair follicles stand upright, closing the skin's pores and keeping in warmth. Blood vessels, being tiny pipes, pump fresh blood containing oxygen and nutrients through the skin – contributing to its colour.

As observed during my investigations using microscopic imaging technologies, skin is different in different parts of the human body, nevertheless it is fundamentally of a similar structure throughout (Fig 60-66). 'There are many local variations in thickness, mechanical strength, softness, flexibility, degree of keratinization, sizes and numbers of hair, frequency and types of glands, pigmentation, vascularity, innervation and other features.'[5]

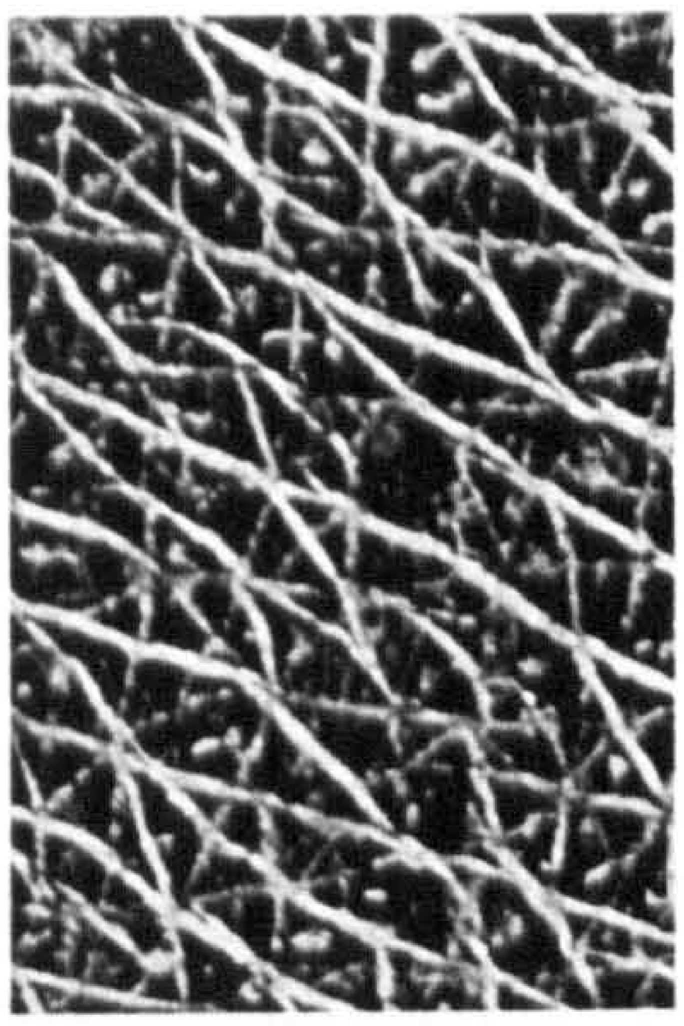
In contrast to the rest of the skin there are characteristic elevated ridge patterns on the surface of fingers and toes, and the palms and soles that do not change during the life path of a person. Fingerprints were already used in China during the Tang dynasty (618-906 AD) for the purpose of identification of a person. Hundreds of years ago in Tibet fingerprints were used as a form of signature to sign important agreements.[6]



58 Skin.
This organ has a layered structure, which in turn is further stratified.



59 Layers of skin: linear representation of the structures within the skin tissue (left), architecture of blood vessels (right). E = Epidermis, D = Dermis, Sc = Subcutis.



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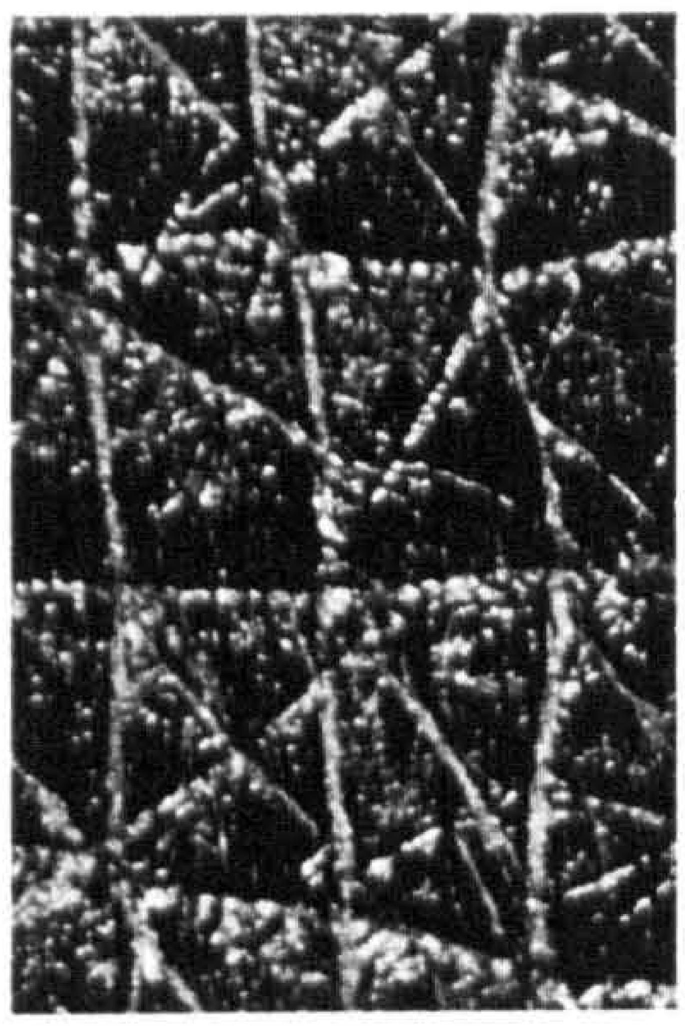

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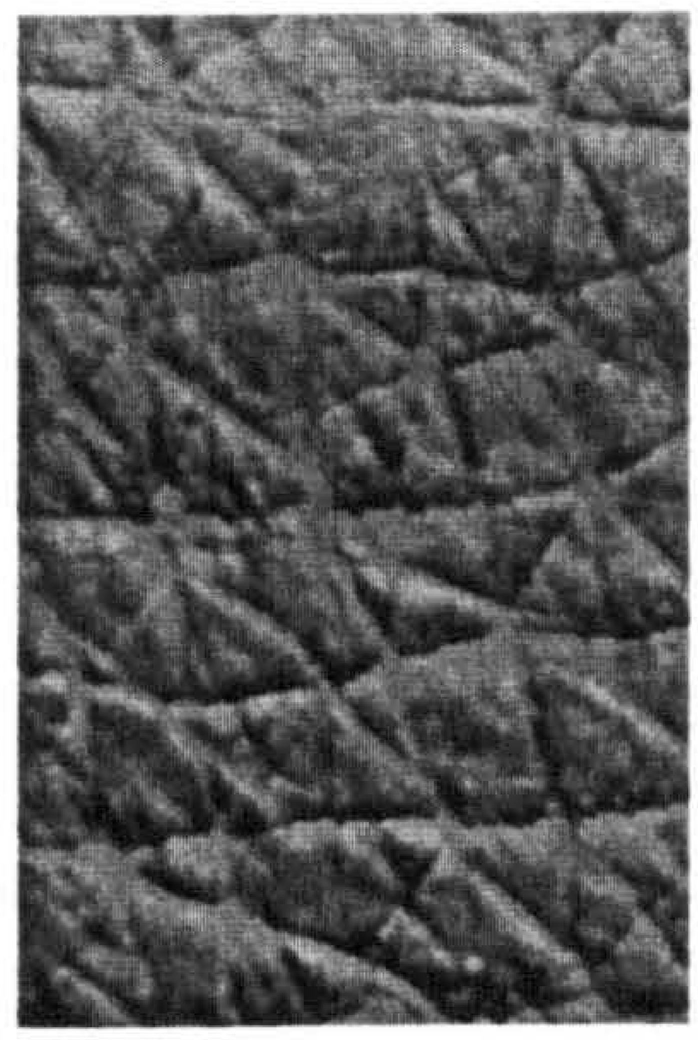

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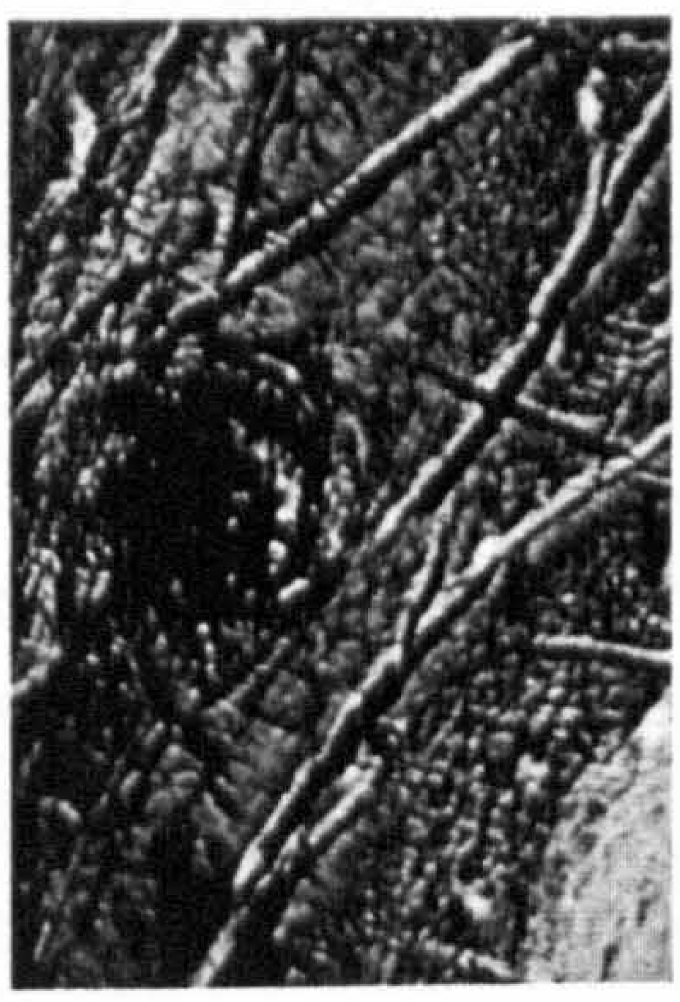

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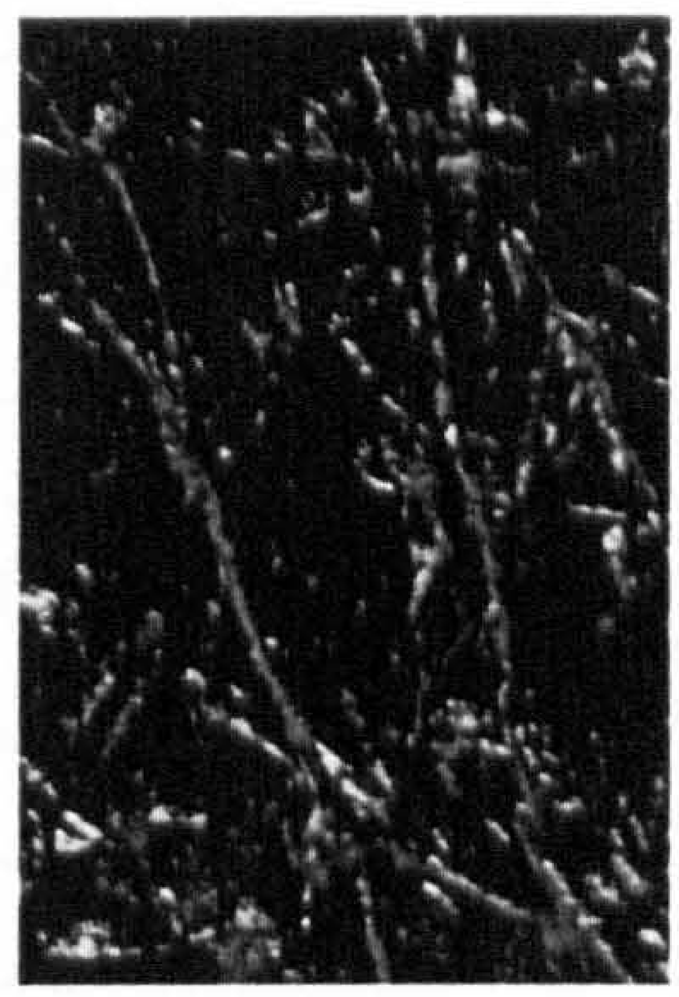

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As observed during my investigations using microscopic imaging technologies, skin is different in different parts of the human body, nevertheless it is fundamentally of a similar structure throughout:

60 Skin surface pattern, human hand, low magnification.

61 Skin surface pattern, human hand, medium magnification.

62 Skin surface pattern, human hand, low magnification.

63 Skin surface pattern, human forehead, high magnification.

64 Skin surface pattern, human forehead, medium magnification.

65 Skin surface pattern, human forehead, low magnification.

In contrast to the rest of the skin there are characteristic elevated ridge patterns on the surface of our fingers and toes, and the palms and soles that do not change during the life path of a person:

66 Close up of a human finger showing the pattern of whorls and ridges making up the fingerprint.

04.2 THE MAIN FUNCTIONS OF THE SKIN

My research seeks to explore particular aspects of the human skin and their potential replication within textiles and the environment. The features of skin are as follows:

serves as a barrier to physical agents (protects the internal organs from physical damage)
protects against mechanical and thermal injury
prevents dehydration of body through fluid loss (regulates the quantity of water and salt in the body)
acts as a sensory organ being rich in nerve endings and specialised sensory receptors
provides a surface for grip
stores and metabolises fat
helps regulate body temperature
reduces the penetration of UV radiation
acts as an outpost for immune surveillance (protects the internal organs from bacterial infection)
is a self healing system
signals many illnesses and diseases
is a production site of pheromones – chemical messages influencing our physiology and behaviour
plays a role in biochemical reactions, best known for Vitamin D synthesis from sunlight
has a cosmetic and sexual appeal (sociosexual communication)
acts as a communicator of our feelings (responsive and interactive membrane)

Table 3
Functions of the skin.
The aspects highlighted in bold print I have selected for inclusion in my practical work.

Protection

One of the most essential functions of skin is to protect our body. The epidermis is waterproof and therefore prevents water entry to the body or loss of vital body fluids. Skin is a significant primary site of immunosurveillance and prevents the entry of harmful bacteria and viruses as well as initiating the primary immune response. The epidermis also produces the pigment melanin, which protects the body from harmful ultraviolet radiation. 'Within limits, it [skin] forms an effective barrier against mechanical, chemical, osmotic, thermal and photic damage. It is capable of absorption and excretion, and is selectively and regionally permeable to a variety of chemical substances.'[7]

Thermoregulation

Skin is the body's main organ of heat control and plays a crucial role in regulating temperature through the direct heat loss from its surface and by the evaporation of sweat. Equally the fat layer under the dermis contributes to heat insulation for the body.

To a large extent the direct loss of body heat, and therefore the skin temperature itself, is regulated by blood flow. Surface capillaries have the ability to open in warm weather to flush the skin surface with blood assisting cooling, or close in cold weather restricting blood flow and conserving heat: vasodilatation = more blood flow = higher direct heat loss; vasoconstriction = less blood flow = reduced heat loss.[8] The sweating process also plays a useful role in the cooling of the skin through evaporation. The cutis excretes water, minerals and some urea, so helping to regulate the body temperature. The minimum daily perspiration is about 0.5 litres up to maximum of 10 litres of daily secretion, with a maximum output of 2 litres/hour.[9] 'Sweating may also occur in response to emotion or after eating spicy food.'[10] In addition, besides assisting thermoregulation, sweat also maintains hydration of the stratum corneum and improves the grip on our palms and soles.[11]

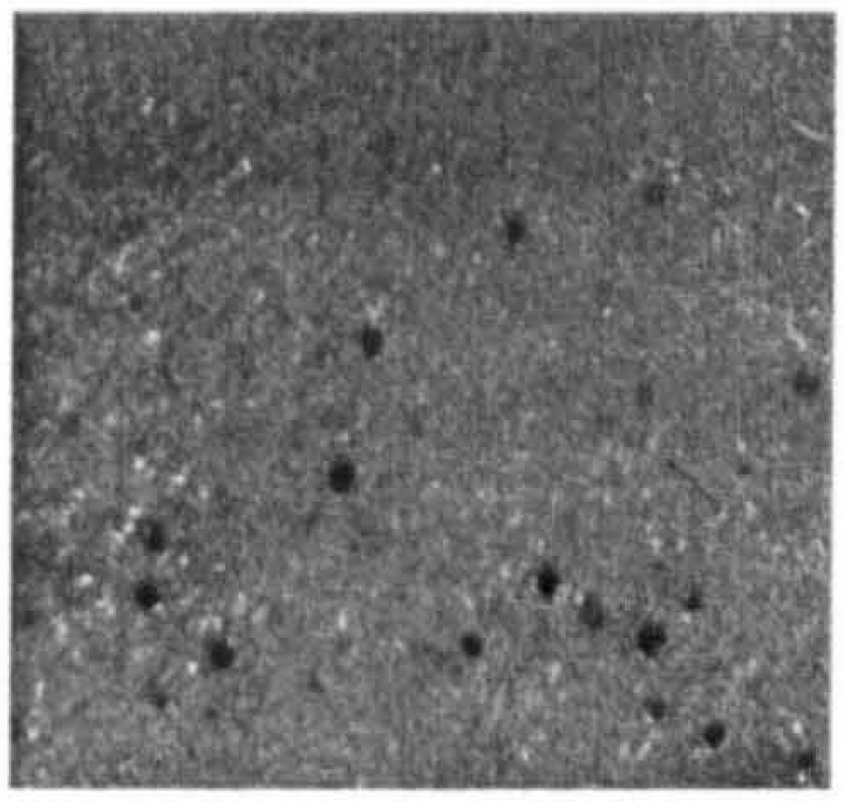
Immunological surveillance and biochemical reactions

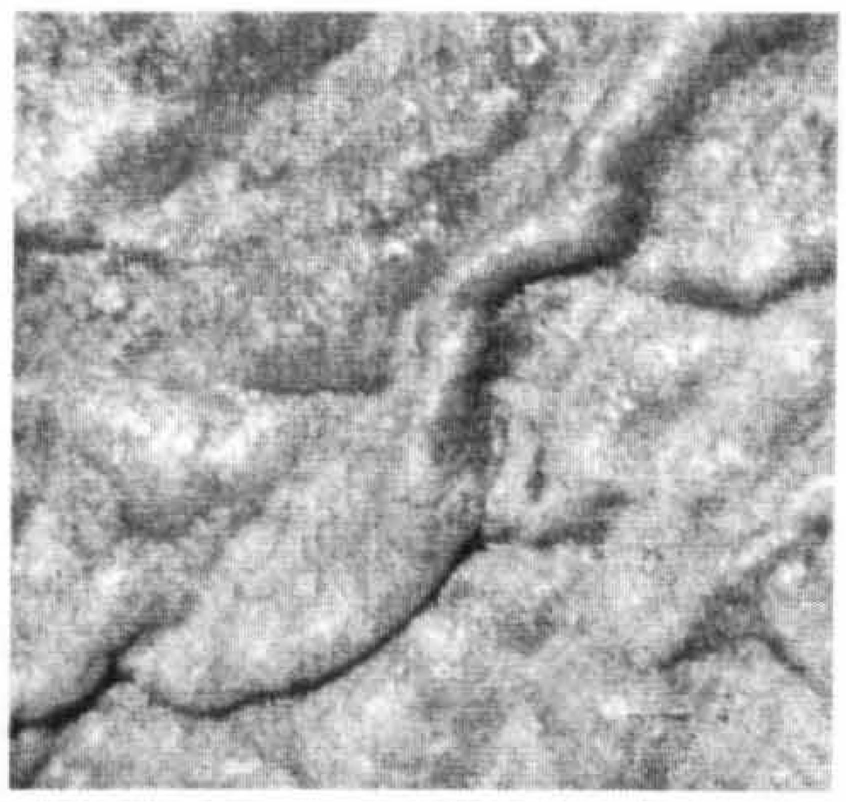
The skin contains immunologically competent cells and is an important primary site of immunosurveillance against the entry of antigens as well as initiator of the primary immune response.[12] 'These complex interactions are governed by an individual's genetics.'[13] Regarding biochemical reactions, the best-known example is the skin's role in vitamin D synthesis under the influence of ultraviolet B (UVB) radiation. The skin is also involved in androgen degradation (metabolism) and other biochemical reactions being the target of a variety of hormones and for vitamin A.[14]

67 Diagram drawing of sense organs.

The stimuli from the skin surface are sent to the brain, which decides what action to take. Those areas of the skin that contain many sensory receptors receive more attention from the brain.

The linear drawing shows what meaning each body part has in our brain.

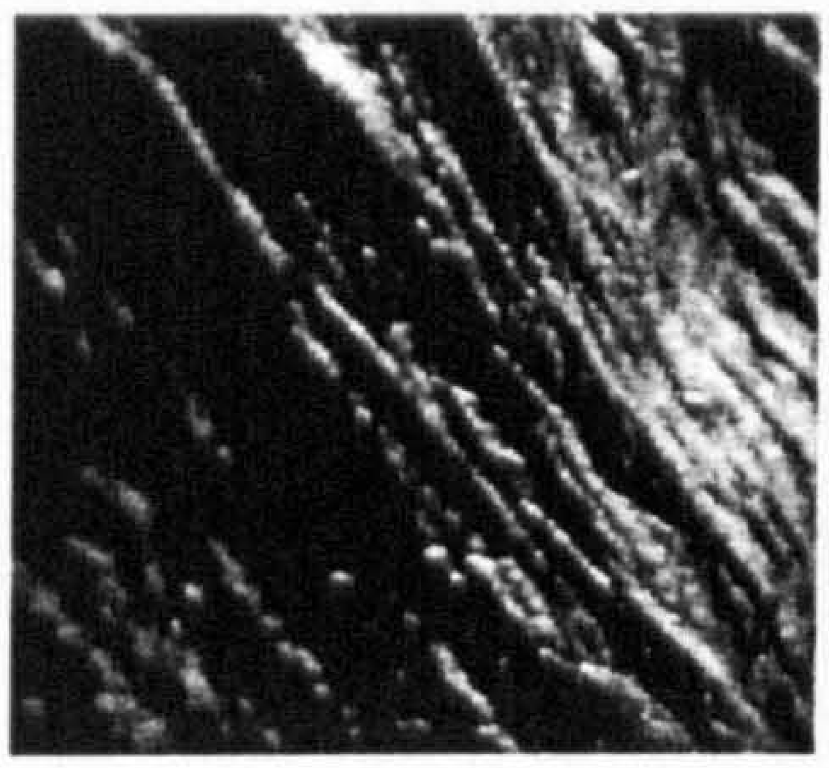


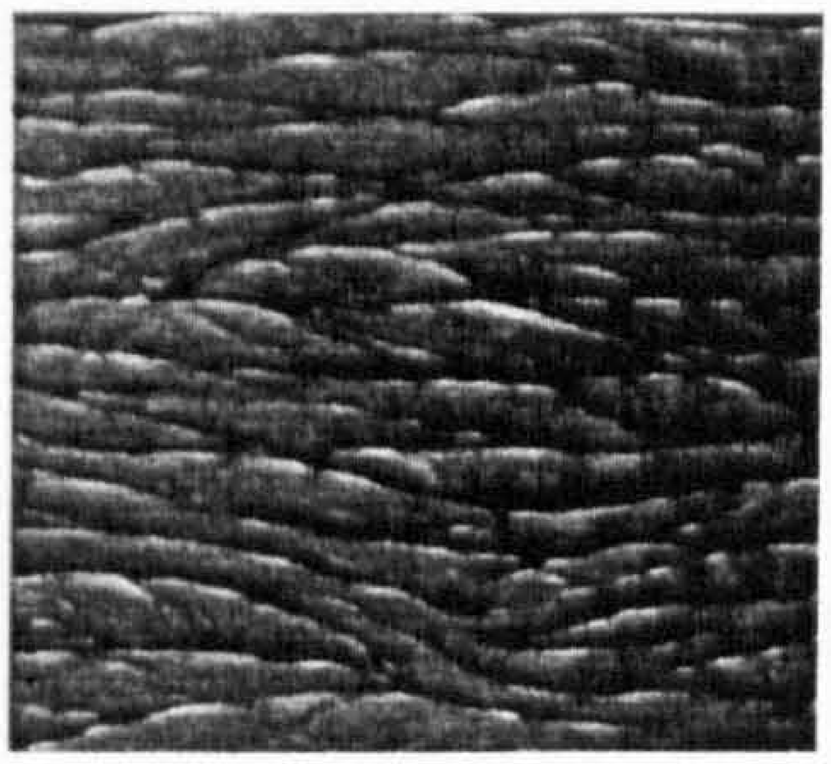


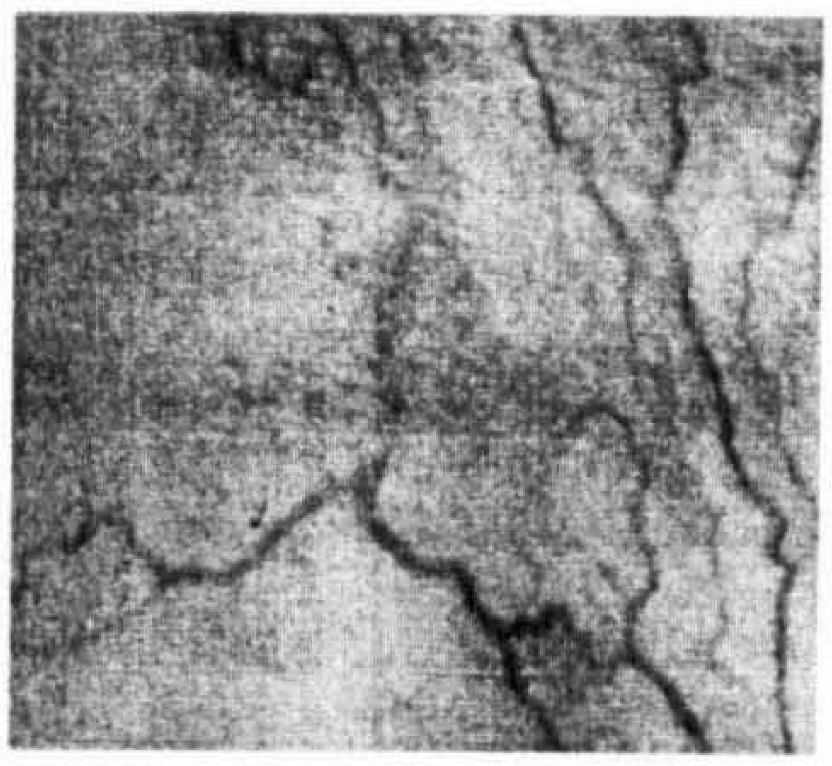
68 Blackheads appear when hair follicles become plugged with dried sebum.

69 Elderly skin. Keratosis.

70 Ageing skin, elderly female. Neck is showing typical creasing appearance.







71 Close up of wrinkled skin on the hand of an elderly man demonstrates how translucent and delicate it has become.

72 Surface structure of the skin, normal anatomy.

73 Alcoholic disease, spider navel. Close up of an elderly female's skin.

Sensation

The skin is a sense organ (Fig 67). It is rich in nerve endings and specialised sensory receptors, remaining in constant contact with the brain.[15] It clearly registers touch, pressure, pain and their intensity as well as identifies changes in temperature. 'All of these sensations are recorded and interpreted by a wide variety of specialized neurons distributed throughout the [...] nervous system'[16] and instantly communicated to the brain, which decides what action to take. 'The same nerve fibres that carry pain also carry the sensation of itch. This sensation, which is unique to the skin, causes considerable distress when it becomes persistent and severe.'[17] In some locations such as finger tips, toes, lips and tongue, skin is particularly sensitive.

Social signalising

Not to be overlooked, is the role of skin as a social communicator of our personal identity, self-image, age, gender, state of health and much more. In the case of facial skin it can signal emotional states by means of muscular and vascular responses.[18] Skin is vitally important to our whole system of interacting with others as disorders of the skin worsen the individual's sense of well-being and self-worth.[19] 'Herein lies the concept of 'mind and skin' in the interpretation and treatment of many dermatological disorders [...].'[20] Often the abnormalities of a physiological character, reflected in the appearance and condition of the skin, can cause psychological problems leading to psychopathology. The concept of 'normality' is closely connected with the notion of what is socially acceptable, good and beautiful, and what is not.

04.3 BIOLOGICAL SKIN CONDITIONS

There are various physiological conditions of skin ranging from healthy skin, young and older skin to stressed, injured and diseased skin, which all influence and define our appearance (Fig 68-73). In our social interactions with other people we can usually 'read' the skin and identify such things as sex, age, race and often even emotional state or health condition without being dermatologists or other specialists - just by relying on our own social competence and experience.

One of the first things we see is the colour of the skin. Skin colours range from shades of black through browns, yellows, olives, rose, greys and purples to various shades of white.[21] 'The colour of human skin derives from and varies with the amount of blood and its degree of oxygenation in the cutaneous circulation, the thickness of the stratum corneum, and the activity of specialised cells producing the pigment, melanin.

[...] Radical variations in colour are mainly due to differences in the amount, type and distribution of melanin, and are genetically determined.'[22] Apart from this, there are also other aspects which can temporarily influence the colour of the facial skin. Strong emotions such as hate, embarrassment, fear or shame may make us blush, flush or become pale.

CHAPTER 05 ::

SENSORY SKIN

05 SENSORY SKIN

'We are social beings, and we communicate in and with and through our senses. Long before we are rational beings, humans are sensing beings. Life without senses does not make sense.'[1] ***Anthony Synnott, sociologist***

Skin is our largest and at the same time most extensive sensor with a total weight of approximately 5 kg in adults. 'The human exterior is itself a sensory organ.'[2] It is our interface with the environment. We identify ourselves and our surroundings through our senses. This is essential for our orientation and ability to act.

> 'Skin is our interface with the world.
> We communicate with our skin.
> We feel with our skin.
> Skin is our protection from heat, infection, injury.
> Our skin is the first thing others see.'[3]

As a sense organ skin is both a passive receptor and an active communicator, so it can function simultaneously in both directions - inwards and outwards from the body. The skin registers the incoming stimuli from the outer world, but also very obviously communicates our feelings of shame, fear, stress, anger in the form of colour changes – redness, paleness, red spots, sweat and goose bumps. Because of the physiological function of the skin as a thermoregulator, as an outpost for immune surveillance and protector from fluid loss, it is the only sense organ which is vitally important for our survival.

Scientists are of the opinion that only 30% of our communications are verbal.[4] All the rest is 'body language' spoken by our appearance, gestures, facial expressions, biological odours and certainly by our skin. Very often our first impression of another person proves to be correct. This natural intelligence of our body is sometimes also called intuition.

In my research I examine the human skin as a sensor, contact organ and medium for communications in order to create corresponding and interactive textiles. Therefore in this Chapter I will selectively discuss the biological mechanisms which form and sustain our perception of the outer world including other people under their skins, slightly touching on some psychological and social aspects if needed for a better demonstration of sensory phenomena. For this purpose I have selected three senses: touch, smell and vision. Touch is most commonly associated with the skin's properties, smell is unique to each individual and our skin is a production site of our biological odours, and finally the sense of sight is also important because of the aesthetic qualities of the skin and skin's constant exposure to visibility. Thus before directly looking at the selected senses I would like to pay some attention to the sensorium in general and to the brain which functions as a catalyst of our sensations.

05.1 SENSORY WORLDS

The environment is perceived through the sensory receptors but not all of our sense signals reach our consciousness. We sense more than we are aware of and this influence our emotional, psychological and physical conditions. Commonly we acknowledge five senses: sight, touch, smell, hearing and taste, as first defined by Aristotle (384 – 327 BC), although we do have a sense of balance as well and some consider the intuition to be our seventh sense.[5] Some authorities have calculated even more than that, and the number of senses has varied from 5 to 12 and up to 17.[6] However, in European culture we still feel comfortable with the 'classic five' notion of senses except, crucially, that 'the current thinking about the sensorium tends to emphasise not the fallibility of the senses but their utility.'[7] Since Georg Simmel pioneered his sociology of the senses in 1908, the importance of the senses has become an increasingly subject to debate.[8] As a consequence of this, thinking on the previously neglected 'primitive' senses has been gradually reformed.

Sight Hearing Smell	Human
Taste Touch	Animal

Table 4
The Aristotelian hierarchical order of the senses. The three human senses are so-called 'distant' senses and are therefore regarded as pure and moral as opposed to the two lower 'animal' senses.

For some people one of the senses might become more prevalent over the others. Artists and photographers are visually orientated, but musicians will be more sensitive to audio stimuli. '... [P]sychologists suggest that the senses characterize different 'kinds of people'; [...] Anthony Robbins (1987)[9] says that people tend to access their brain in either visual, auditory or kinesthetic modalities; but Tardif (1989)[10] thinks that there are only two types of people: eye people and ear people.'[11]

Usually we only realise the meaning of our senses when they do not function as we are used to. For instance, only when we enter a dark room are we forced to understand that our perception of the world is mainly visual. 'In sum, we all live in very different sensory worlds'[12], varying from individual to individual and from culture to culture.

05.2 SKIN AND MIND

Skin is a mirror of our physical and psychological health – it reflects our emotional state. Scientists and dermatologists have proved the existence of a clear link between our skin and our nervous system. Author of 'The Ageing Skin' Dev Basra writes on the development of the skin: 'Parts of the skin originate from types of embryonic cells called ectoderm cells; in fact, the whole of the epithelium is formed from ectoderm cells. [...] It is true to say that practically the whole nervous system originates from the ectoderm – thus there is an embryonic link between the skin and the brain.'[13] Dev Basra continues: 'A person's mental state is also reflected clearly in his or her skin; the colour of the skin for instance becomes red or very intensely-coloured with rage and absolutely white or pale with fright. On the other hand, inner peace, joy, love and enthusiasm give the skin a radiant glow.'[14] Also we know from our experience that allergy, rash and some other skin traumas are sometimes of a psychosomatic character.

However, the psychosomatic understanding of skin is relatively new and was pioneered by Sigmund Freud in the beginning of the 20th century. Freud's ideas of the self and the body were brought forward by the French psychoanalyst Didier Anzieu by introducing a new 'skin dimension'. He offers the current notion on the nature of the self by emphasising the relation between the experiences of the skin and the formation of the ego. The concept of the skin ego by Anzieu suggests a method of understanding the psychical properties of the skin. He defines the skin ego as 'a mental image of which the ego of the child makes use during the early phases of its development to represent itself as an ego containing psychical contents, on the basis of the experience of the surface of the body.'[15]

Biomedical investigations on the skin are progressing rapidly in scope and volume, and also prove the skin-mind link from the biochemical point of view. In 1997 schizophrenia researchers at the Craig Dunain Hospital in Inverness claimed to be able to identify whether or not a patient is schizophrenic by examining his or her skin. For this purpose they have developed a 'niacin skin flush test,' which is based on the scientific prelim that schizophrenic's cell membranes have reduced levels of fatty acids.[16]

In scientific terms the processes of people's lives and the decisions taken are determined by chemical reactions in the body.[17] These influence our temper, relationships, state of health and much more. For example, our perception of another person, not influenced by the norms of modern society but based on our basic biological instincts, is consequently highly individual. The same is true for environments in that we live, work or relax. Therefore, new design concepts are becoming increasingly concerned with sensory issues. It is possible to enhance our wellbeing and quality of life by designing responsive environments and clothing, which respect our biological senses. My research is also concerned with these issues as I will demonstrate in the Part II when discussing my textiles practice.

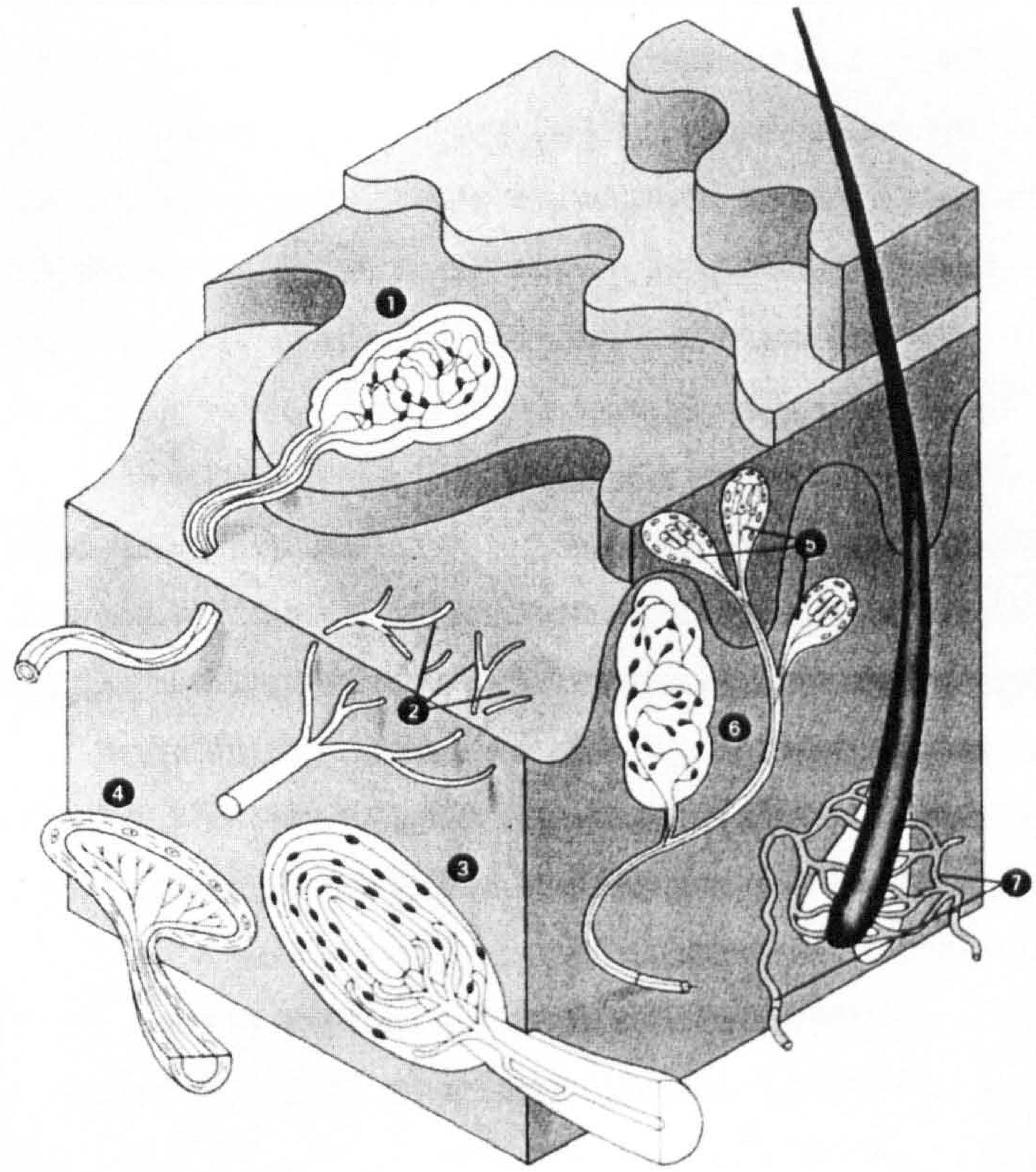
05.3 SKIN AND HAND

The Chemistry of Touch

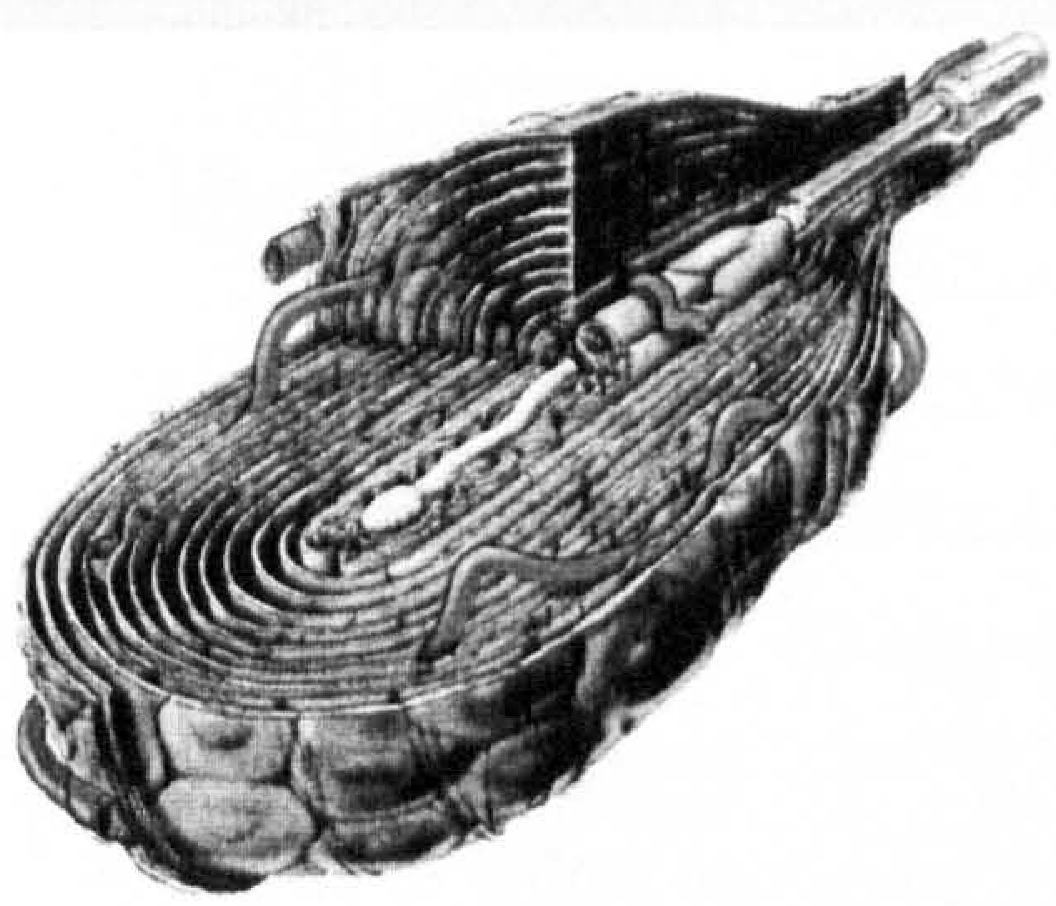
'Textural surfaces form an integral part of a child's world of learning. They can aid a partially sighted patient to navigate through space, form a blind persons total environment, and indeed assist a mental health patient's transition from an ethereal world to reality.'[18] *Richard Mazuch, healthcare architect*

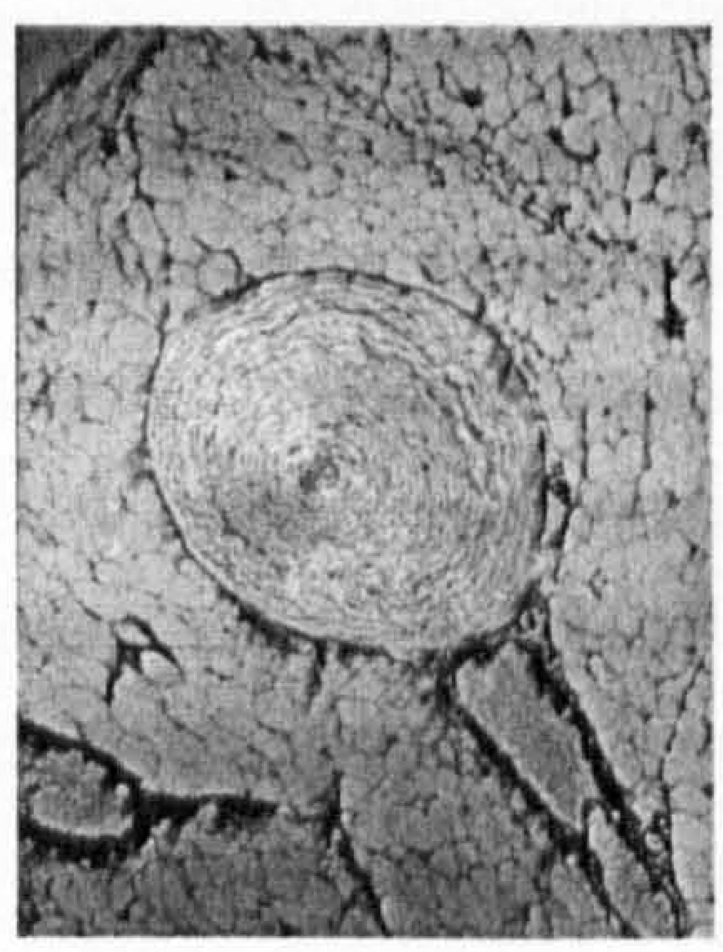
Touch is the first sense we develop. The skin teaches the child where he 'starts' and where he 'ends'; where his borders are.[19] But it was only in the nineties that it was empirically proved by specialists that body contact is absolutely important for the healthy development of an infant. Now it is acknowledged that stroking, cuddling and touching helps babies to evolve higher intelligence and reduces stress when they become adults.[20] Touch is essential for people's well-being in general.

From experience we know that caresses reduce stress and produce positive emotions. During the process of stroking, our brain is producing the hormone Oxytocin, which is also called the 'love hormone', pain and stress levels are reduced and blood pressure falls.[21] Touch is also the 'confirmatory' sense that collect information confirming data received by the other senses. It helps us to survive and act in space.[22] As sociologist Georg Simmel says, the sense of touch is our actual sense of reality. Only that what we can or could physically grasp embodies true reality for us.



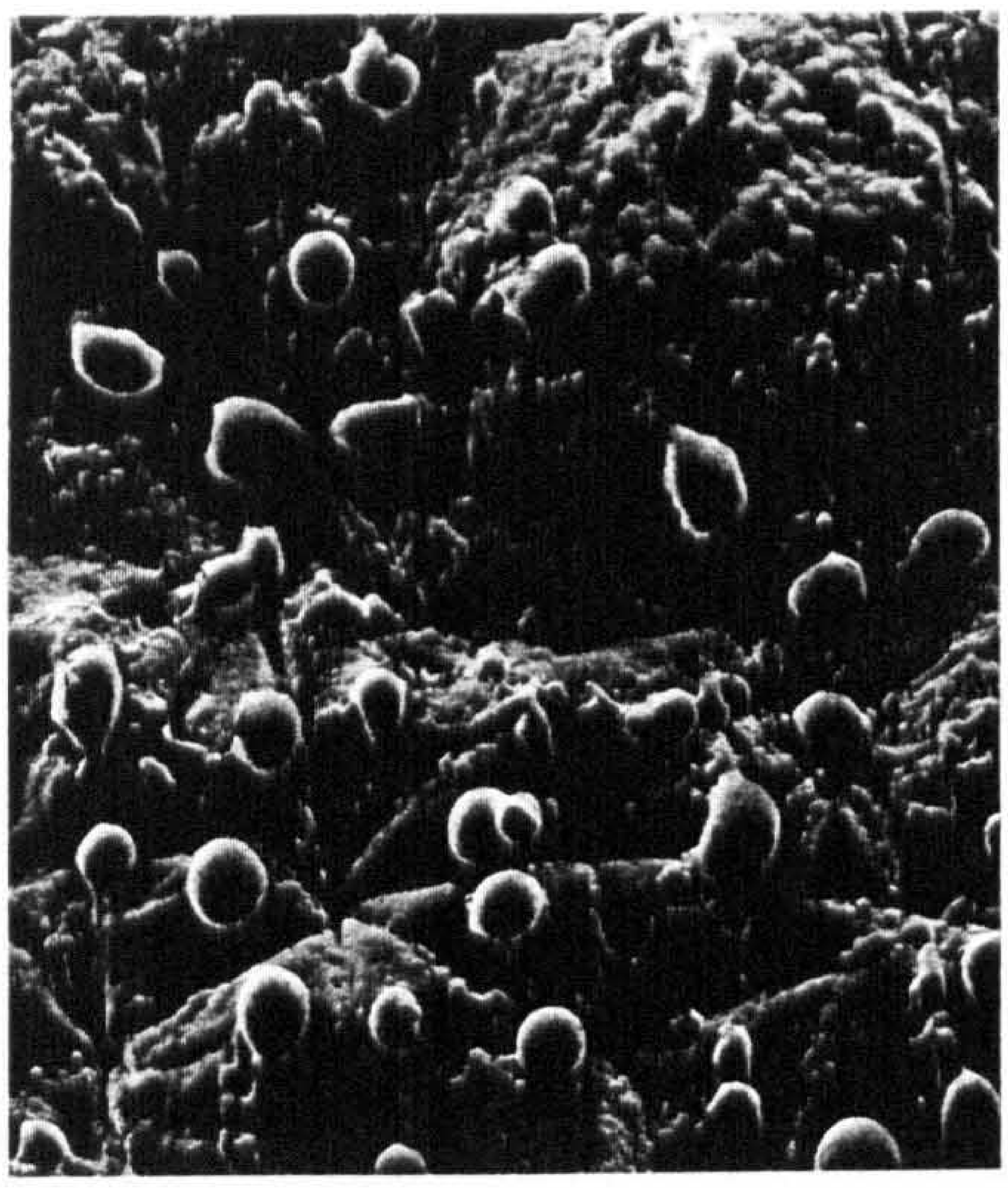
74 Skin receptors.
1 = Krause's bulb, 2 = Free nerve endings, 3 = Pacinian corpucle, 4 = Ruffini's corpucle, 5 = Merkel's disks, 6 = Meissner's corpucle, 7 = Hair follicles' endings.

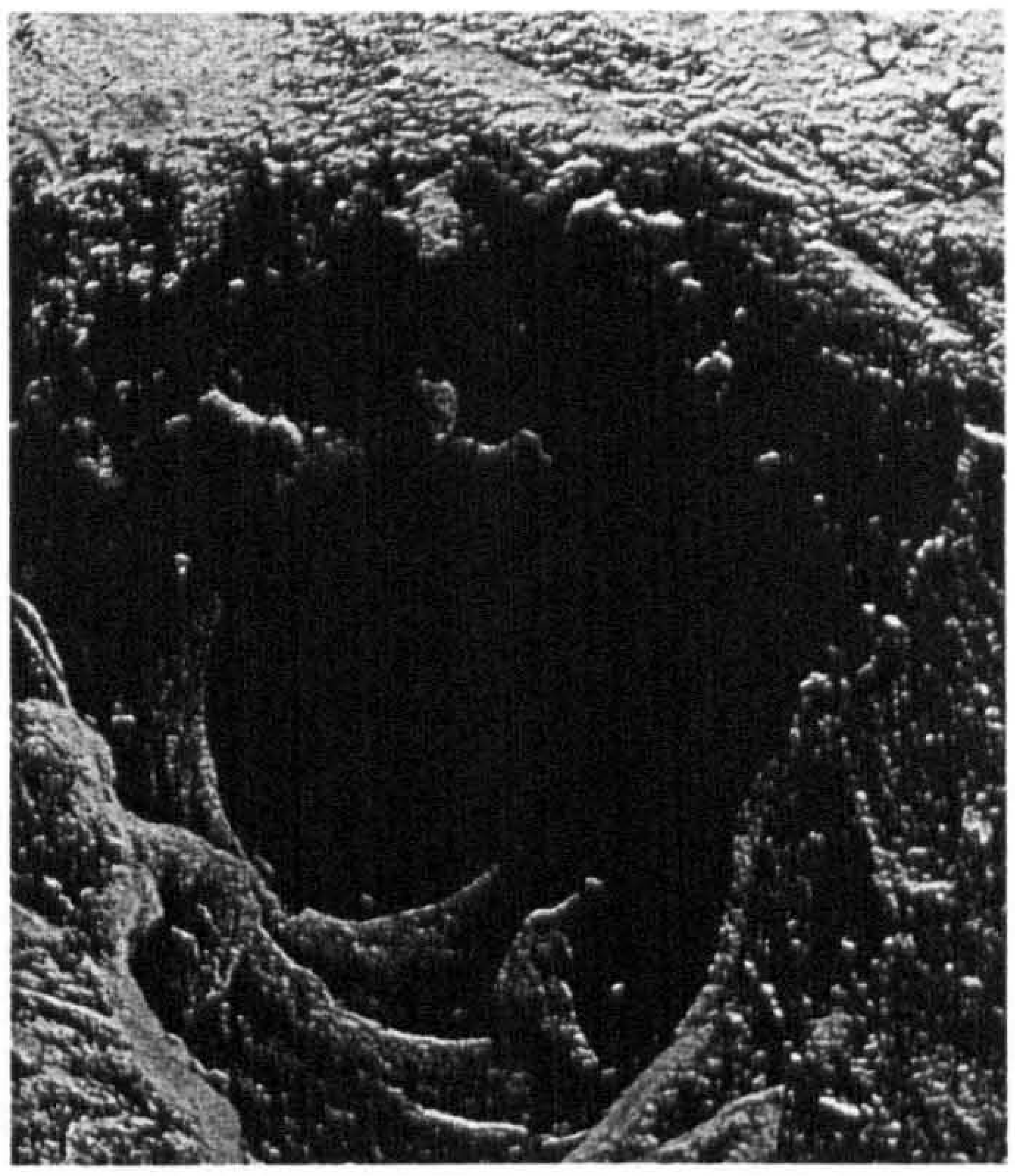




75 Pacinian corpuscle enables us to feel pressure. Drawing.

76 Pacinian corpuscle, human skin tissue, light micrograph.





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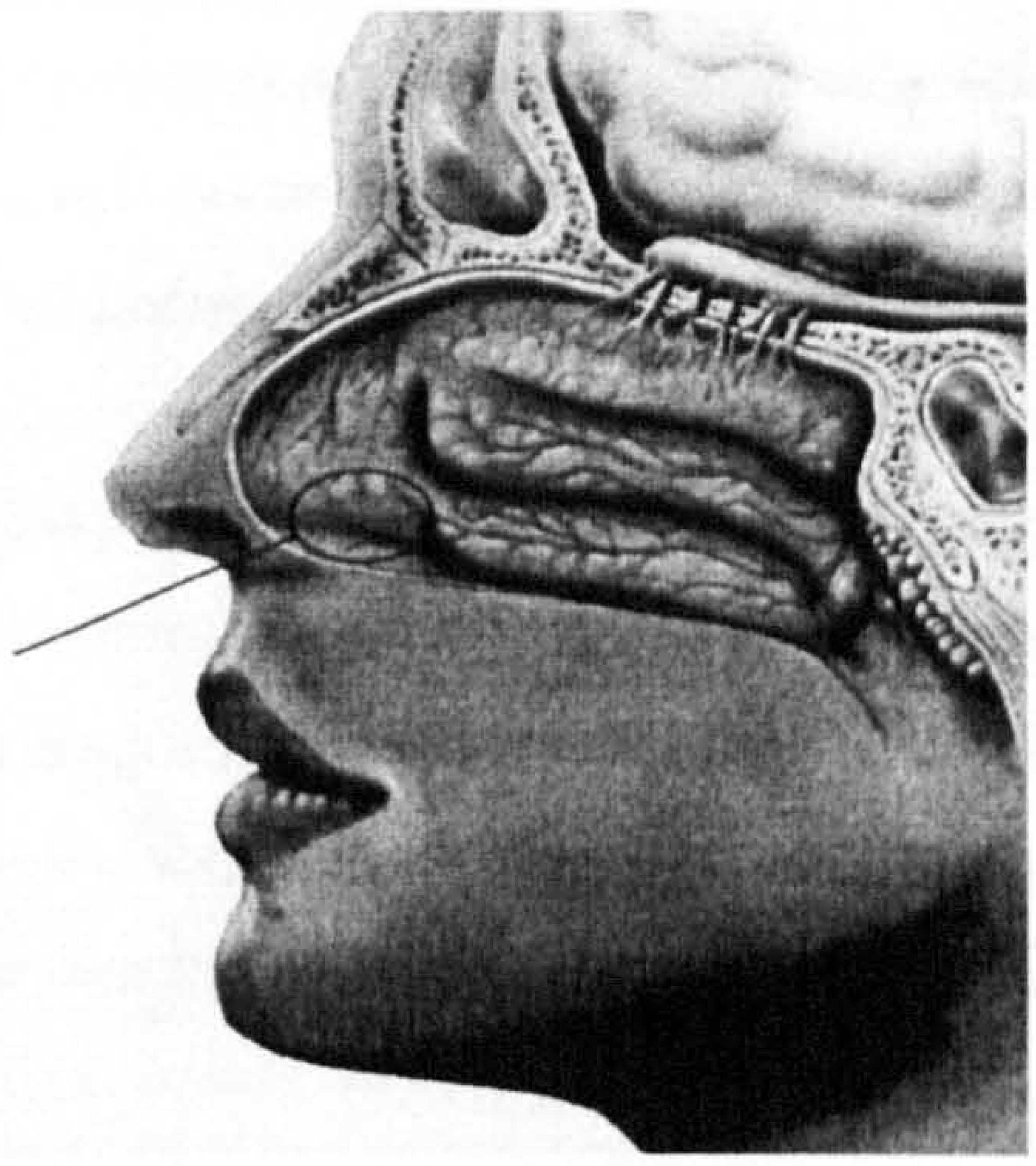

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77 Sweat droplets on the surface of the skin (hand). These are emerging from the entrance of the many sweat glands that lie in the dermis of the skin. Secretion of sweat is a method of controlling body temperature. One quarter of the body's heat loss comes about by sweating. Coloured scanning electron micrograph. Low magnification.

78 A sweat pore in the skin obtained from a blister on the palm of a man's hand. Coloured scanning electron micrograph.
High magnification.

79 The sense of smell. Here skin from the nose is seen in section, showing the area of tissue in the nasal cavity where the olfactory cells are located (purple). Beneath is a layer of connective tissue containing nerve fibres, blood vessels and serum-producing glands. Light micrograph. Low magnification.

80 Scietists believe that our nose is a sexual organ. It registers the odourless chemical messages - pheromones - and sends the information to our brain.

Skin is intelligent. It can 'read'. If you would ask someone to write a name on your back, no doubt, you would be able to 'feel' the name without problems. What we feel on our skin mainly consists of several impulses together (Fig 74). Through four different types of touch cells we are able to distinguish vibration, itching, pressure, touch and stretching. Besides that with various receptors we can feel pain, warmth and cold.[23] In the epidermis, sensory nerve endings may end on Merkel cells which detect pain, itch and temperature. So in addition to feeling the touch of an object on the skin we are able to tell whether it is hot or cold. In the middle layer of the skin there are specialized corpuscular receptors such as Pacinian corpuscles (Fig 75,76), which enable us to feel pressure and vibration and Meissner's corpuscles, which are touch sensitive and mainly located in the hands and feet.[24]

Skin and touch are often a source of strong metaphors in all languages, embodying both social and physical meanings. We are used to saying that someone has 'thick' or 'thin' skin, defining mostly their social sensitivity. We say 'it was so touching!' if something has been particularly emotional. Overall there are plenty of skin and touch related tactile metaphors which are usually used to describe our feelings, sensitivities, emotions and interactions with others.[25] Sometimes we use the skin metaphor when talking about our identities. For example, 'he was not comfortable in his skin' is said if someone feels awkward in a particular situation.

The language in literature has been also occupied with the presence of skin. There are beautifully written pieces on skin and touch such as Roland Barthes essay on 'Talking – Déclaration' in which he is using the language-skin metaphor. Here the written text itself becomes extremely tactile and sensual, very erotic and almost physical: 'Language is a skin: I rub my language against the other. It is as if I had words instead of fingers, or fingers at the tip of my words. My language trembles with desire. The emotions derive from a double contact: on the one hand, a whole activity of discourse discreetly, indirectly focuses upon a single signified, which is 'I desire you,' and releases, nourishes, ramifies it to the point of explosion (language experiences orgasm upon touching itself); on the other hand, I enwrap the other in my words, I caress, brush against, talk up this contact, I extend myself to make commentary to which I submit the relation endure.'[26]

05.4 SKIN AND SMELL

The Olfactory Sensations

'[T]here is whole world of social and psychological interaction going on at the level of olfaction that we know almost nothing about.'[27] ***George Dodd, a scientist and perfumer***

The olfactory sense is one of our 'distant' senses like hearing and seeing.[28] It is also one of the most primitive senses and while we are sometimes able to catch a scent from very far away, in this capacity we lag far behind most mammals.

In total we are able to distinguish up to 10,000 aromas.[29] In the mucuous membrane of our noses on tiny hairs there are around 10 million smell cells (Fig 79). They pick up scent molecules, chemically dissolve them and send them from the smell nerve further to the area in brain which is responsible for our emotions. Our individual bodily smells are quite unique, too. Humans have two types of sweat glands: eccrine and apocrine, each with very different functions. Both types of sweat are initially odourless upon production, only beginning to smell when broken down by bacteria on the skin surface (Fig 77, 78).

The eccrine sweat glands are found all over the body located deep in the dermis and produce a watery secretion.[30] The evaporation of the fluid from the skin helps to keep the body cool, whereas sweating regulates the temperature. This process is continuous, but sweating becomes noticeable when secretion levels increase in response to hot conditions or physical exercise.[31]

Apocrine glands are another specialised glands. They differ from the eccrine glands as they open into hair follicles and are larger glands. 'They have no role in temperature regulation but are related to the scent glands of animals, and are thought to function solely for odour secretion. They are not stimulated by heat but by stress and emotion, including sexual excitement'[32] Skin is the production site of pheromones - our highly individual odour signatures, which in fact '[...] are odourless chemical messengers secreted by animals and humans and are picked up by the nose at a subconscious level.'[33] These influence our hormone levels, psychology and behaviour.

Scientists have proved that the olfactory sense is well developed in all kind of mammals but particularly in females, including humans (Fig 80). This is a natural feature, in order to help select the right partner for the most biologically important task - qualitative successors. As written in the German magazine GEO: 'Women simply smell the right man.[...]Masculine skin transmits certain scent signals, which are differently mixed in each individual. The woman's brain unconsciously registers if the chemistry is right.'[34] These biologically clever decisions explain 'love at first sight.' A range of experiments was carried out at the University of Bern to analyse the reactions of women to sweaty T-shirts from different men. These tests proved that the human female finds the male sexually attractive if he is very divergent from her in one respect – in the mix of his immune-genes. 'The higher the diversity of the child's MHC-genes [Major Histocompatibility Complex genes or immune-genes] inherited from his parents, the greater his resistance against different irritations,'[35] comments Claus Wedekind, a zoologist from Switzerland. The results of the experiment demonstrate how important the olfactory sense can be in decision-making situations, unconsciously influencing our judgement.

Besides this, the sense of smell has the greatest capacity to provoke our feelings and memories in the quickest manner. '...[I]t [smell] is [...] the one most directly connected to the subconscious layers of the psyche and of memory, and for many it is the one that triggers memories the most: sometimes a simple smell is enough to relive a scene from the past and to feel all the emotions associated with it.'[36] Smell may therefore 'affect moods and emotions, improve work performance, reduce stress, promote relaxation and enhance social and sexual relations.'[37]

This 'magical' aspect of olfaction can be used in many ways including morally debatable ones as described in the book Body Bazaar: The Market for Human Tissue in the Biotechnology Age by Andrews & Nelkin. 'In recent years, biotechnology techniques have transformed human body tissues into marketable research materials and clinical products. Kiotech, a British biotechnology firm, found a commercial use of the human chemical secretions, or pheromones, that purportedly attract members of the opposite sex. They produce Xcite! – moist towelettes soaked with human sexual pheromones harvested from people's sweat.'[38] There are also modern marketing concepts which, for better sales, are introducing special scent compositions in boutiques and stores, particularly in fashion and life-style businesses. Perfumes and music talk directly to the emotions.

The use of fragrances has a long history dating back to the ancient Egyptians, Romans and Greeks who discovered the benefits of aromatic plants.[39] Ever since fragrances have been used extensively in religious, social and political rituals, to mask malodours, in food preparation, in aromatherapy and by the Arabs as a component in the mortar for the construction of certain mosques.[40] Modern Japanese companies are using certain fragrances to improve work performance of their employees.

For instance a contracting firm Kajima has coupled up with a perfume manufacturer Shiseido to produce a unique air conditioning system in the Kajima HQ in Tokyo. 'The system emits citrus smells that invigorate staff early in the morning followed by floral smells that air concentration and then woodland smells at lunch time to relax. The same cycle commences after lunch.'[41]

To conclude this section on the least valued, the least researched and most subliminal of all the senses, the quote from sociologist Anthony Synnott is appropriate: 'Smelling good and smelling bad are constituent elements in the presentation of the self and the construction of the other, whether these odours are natural, manufactured or symbolic. Thus people attract and repel each other. The profound intimacy of olfaction and perfume lies in the fact that one person is breathing and inhaling the emanations of another person. Thus the two people become one, in an olfactory sense; and in the empire of odour, the fragrance is the aroma of the soul.'[42]

05.5 SKIN AND EYE

The Visual Culture

Being the first in the sensory hierarchy, vision is our most prevalent human sense. It is located in our eyes but they alone are not enough to enable us to see. 'We see with our brains. We can even 'see' with our brains without any visual input, as in dreams and hallucinations.'[43] Seeing is the only sense which we can consciously turn off by closing our eyes. More than half of all the information entering our brain comes through the eyes.[44]

The dominance of sight is very precisely reflected in our language and the way we perceive the world manifests in the way we speak. "Seeing is believing', we say, as if this is obviously true; and thus we establish sight as the paradigm of belief.'[45] In the same language-vision respect sociologist Anthony Synnott continues that 'our language also witnesses the ocularcentrism of our culture.' Interestingly, in our vocabulary a physical capacity such as sight is frequently equated with purely intellectual features – understanding and knowledge.[46,47] Such vision-related expressions as 'he has an insight', 'her point of view', 'his vision of things', 'your observation' are used to describe somebody's intellect.

Returning to the skin, it is pertinent to mention that in our culture the skin has never been so present and visible in its own right (value) as it is now. German cultural critic Claudia Benthien comments that relating to cultural history the perception of skin has become increasingly reduced to its visual image.[48] Perhaps we should accept the non-flattering judgement of James Joyce that 'modern man has epidermis rather than a soul.'[49]

'Precisely because of the omnipresence and unlocalized quality of the skin, it is also uniquely exposed to the operations of the other senses, and particularly those of the eye.'[50] I can see the other's skins and others can see my skin. Our skins can 'understand' each other or not. The skin is an important carrier of visual information which gives us clues about a person's health, social status and much more. 'It is what we see and know of others and ourselves. We show ourselves in and on our skins, and our skins figure out the things we are and mean; our health, our youth, our beauty, power, enjoyment, fear, fatigue, embarrassment or suffering. The skin is always written: it is legendary.'[51]

Since the skin plays an important role in socio-sexual communication at close quarters and at a distance and, according to Anzieu, is a representation of both our body and our ego, it becomes a canvas of our identity, self-value and self-image. Our self-assessment is directly linked to the public notion of what is beautiful, good and therefore desirable. These notions vary from culture to culture. The social construct of beauty imposed on the body was discussed in Chapter 03 – Skin as Social Canvas in more detail. In the following Chapter I would like to touch on the issues relating the psychology of skin and body in the context of current technological and biomedical research.

CHAPTER 06 ::

SKIN AS AN INTERFACE FOR SCIENCE, ART AND NEW TECHNOLOGIES

06 SKIN AS AN INTERFACE FOR SCIENCE, ART AND NEW TECHNOLOGIES

'With the cells from one postage stamp-size piece of skin, tens of thousands of pieces can be made.'[1] *Organogenesis*

With the turn of the millennium we have entered a new century – the century of Biology. Significantly, in summer 2000 it was announced that the very essence of a human being – the human genome had been decoded. The previous century of Physics, which formed our traditional perception of the world, prepared the preconditions for the upcoming age by introducing key technologies such as informatics, laser technologies and nano-technologies.

The science of biology has entered our everyday lives. It is forcing us to re-think all those terms, which are essential for our lives and self-confidence: Personality, Identity, Health, Body, Nature, Destiny, Guilt. Inevitably, in the age of artificial cells, genetic engineering, cloning and optimised organisms, the entire idea of life starts to change. Our understanding of ourselves as a bounded selfhood is disappearing: the idea of the skin as a physical boundary between the inner and external or as a definitive border between two bodies has vanished. Genes and organs are transferred and exchanged. Organic tissues are grown in labs. Cybernetic research is becoming evermore complex with technological and human systems advancing towards each other in such a way that it is getting increasingly difficult to distinguish between them.[2] The ethics of genetic engineering has become an important issue. The question is: who will own humankind? (Fig. 81)

After man has 'improved' plants and animals for his own needs, his next agenda is his own evolution. One more boundary is about to fade. Life is no longer the protected bio-pot. The Homo Sapiens is neither on the 'protected' list of nature protection organisations nor on that of National Heritage activists. German essayist Bernd Stoy comments on this issue: 'A time of boundless discovery may be followed by a time of discovery of boundaries.'[3]

In order to inform my research and creative practice on the changing psychology of skin and body in our technology driven society I conducted a survey that comprised issues related to science fiction and biomedical engineering focussing on skin tissue engineering, as well as reviewed artists' works that comment on the body in the new biomedical context. The controversial idea of the technologically enhanced human body to improve its natural performance and appearance has influenced the development of my textiles concerned with the various issues of skin. As it will be discussed in Part II I have introduced smart materials and electronic devices into the new skin-like membranes. Metaphorically this addresses the overall biomedical and technological context and refers to the skin as a technological interface. Technology itself is neither bad or good; what may cause most concern is the use of this technology.

06.1 ARTIFICIAL SKIN

Historically, for a surprisingly long period of time 'there was very little specific attention paid to the skin in early medical conceptions of the body. For many early civilisations, the skin is understood primarily in its role as a covering that keeps the body inviolate.'[4] Skin was a symbol of the entirety of the human body and opening the skin in one way or another was taboo. Greek anatomist and philosopher Aristotle (384-327 BC) explained the skin and its formation as 'a kind of after-effect, brought about by the actions of drying and hardening. The skin is formed, he says, 'by the drying of the flesh, like the scum upon boiled substances; it is so formed not only because it is on the outside, but also because what is glutinous, being unable to evaporate, remains on the surface."[5] This understanding of skin did not change much for many centuries.

Anatomist Andreas Vesalius (1514-1564) (Fig. 82), broke the taboo and started systematic dissections of corpses by investigating the layers of the body with the use of naturalistic methods.[6] Vesalius did not pay much attention to the anatomy of the skin itself. His interest was to incise it, to peel it back and to cast aside, doing this technically as well as possible, not destroying the underlying structures it covered, in order to reveal the much more interesting part of the body – its interior.

Through many changes in the medical and physical perception of skin, finally, at the end of the 18th century, skin started to be considered as an organ itself, with its own structure and functions. The science of dermatology was grounded by classifying skin diseases by their lesions and not according to the part of the body where they appeared.

Through the centuries skin has established its importance and now is being examined within the complex biomedical framework of the body. German Professor of Anatomy Wilhelm Kriz summarises the general research trends in medicine: 'Since the 19th century, anatomy has made the fine structures of organs and tissue the focus of its research with the aid of the microscope, devoted itself to submicroscopic cell and cellular systems in the 20th century and in the meantime is occupied with molecular structures and their functions – as in all other basic subject areas in medicine.'[7]

One of the results of recent biomedical research is the development of an artificial skin for transplantation into humans which, in fact, is not precisely artificial. It is real, living skin grown and nurtured artificially in a laboratory under specialised conditions. Skin cells are extracted from a living source, kept alive, and mass multiplied by stimulating the body's own growth mechanisms.[8] Artificial or living skin consists of two types of human living cells – epidermal keratinocytes and dermal fibroblasts as in the case of the product Apligraft® by Organogenesis, marketed by Novartis (Fig. 86). The manufacturing process enables the skin cells to establish the natural organization they have in skin due to the use of donor cells which are harvested from a circumcised infant's foreskin tissue.[9] Other companies use a polymer scaffold which is seeded with the living skin cells in order to form skin products. Another method introduces 'nonliving material as a temporary barrier, which is applied to a wound to stabilize it and make it receptive to new skin.'[10]

Most people became aware of biomedical engineering, also called tissue engineering – the science of growing living tissue in laboratories to mimic the native tissue being reconstructed, in October 1995. That is when researchers at the University of Massachusetts and the Massachusetts Institute of Technology announced success in growing cartilage in the shape of a human ear on the back of a mouse (Fig.85). The researchers used a porous biodegradable polyester fabric in the shape of an ear to grow living human cells on the back of the mouse. Nourished by the mouse, the cartilage cells grew over the polymer mould which dissolved leaving just the human cartilage in a shape of an ear.[11,12]

Although cells have been cultured or grown outside the body for many years, the possibility of growing complex, three-dimensional tissues – literally replacing the design and function of human tissue – is a recent development.[13] 'This technology will revolutionize the field of reconstructive surgery, allowing the successful regeneration of everything from skin for burn victims, liver for disease victims and ears and noses for people who have lost or disfigured extremities,' claim tissue engineering specialists.[14]

Biomedical engineers have set out to grow virtually every type of human tissue – liver, bone, muscle, cartilage, blood vessels, heart muscles, nerves and more.[15] Commercially produced skin is already available for use in treating patients under the following brand names: Graftskin®, AlloDerm®, XenoDerm®, Apligraft®, TransCyte® and Dermagraft®. Artificial skin transplant, which contributes key properties of the

81 Gene engineers are decoding our patterns of behaviour on a molecular level.

They claim that in the future, couples that want a child, will be able to choose more than the gender of their baby. It will be possible to influence the intelligence (IQ), levels of aggressivity, happiness and many more.

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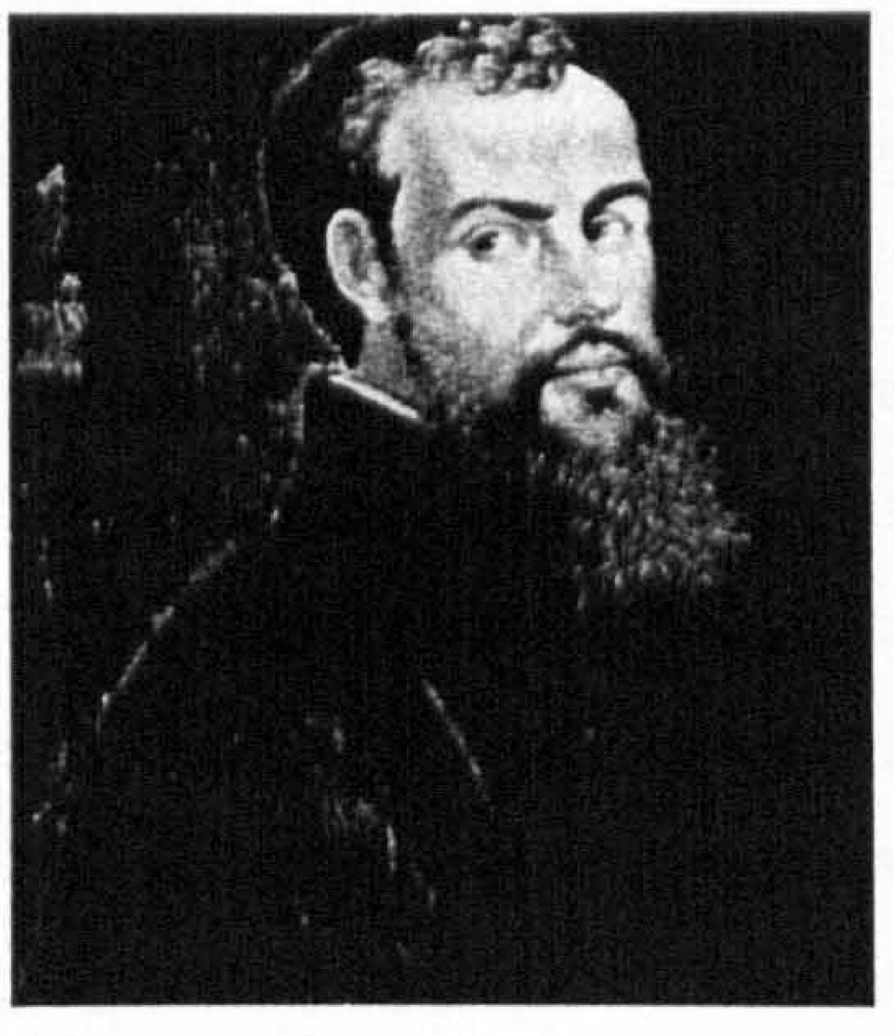


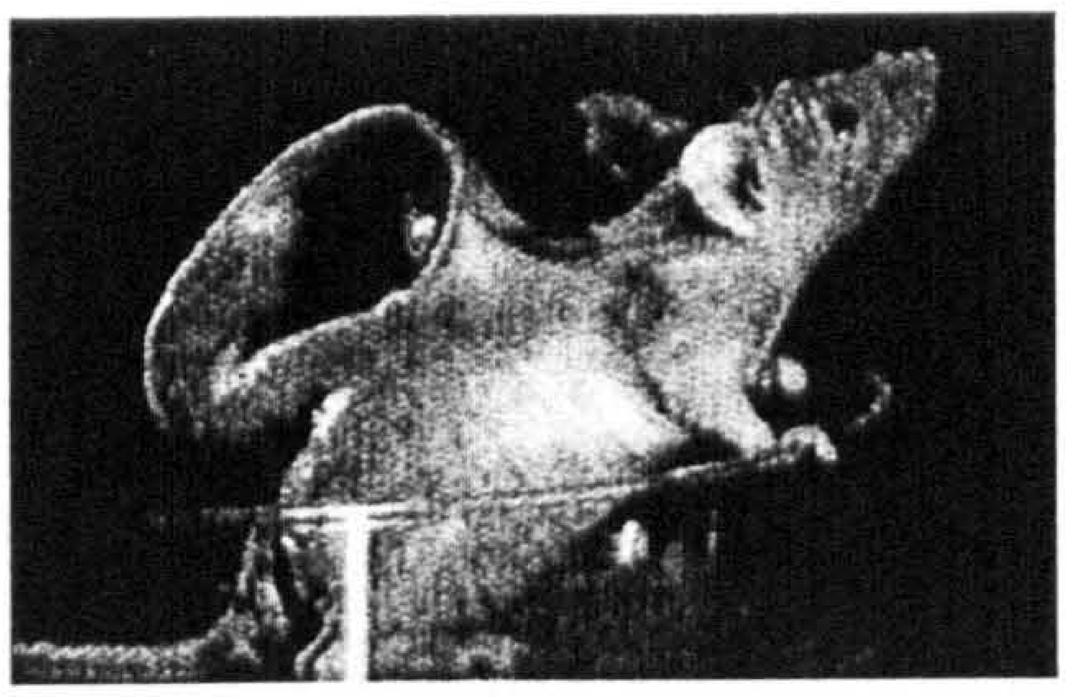
82 Andeas Vesalius (1514 - 1564), founder of the science of anatomy.

During the 16th to 18th centurys skin was seen as something that had to be peeled back and cast aside.

83 Human skin hanging in frame. Frontispiece to Thomas Bartholin, Anatomia Reformata (Leiden, 1651)

84 A Complete Treatise of the Muscles by John Browne, London, 1681.

82, 83], 84]



85 In October 1995, University of Massachusetts and Massachusetts Institute of Technology researchers announced success in growing cartilage in the shape of a human ear on the back of a mouse.

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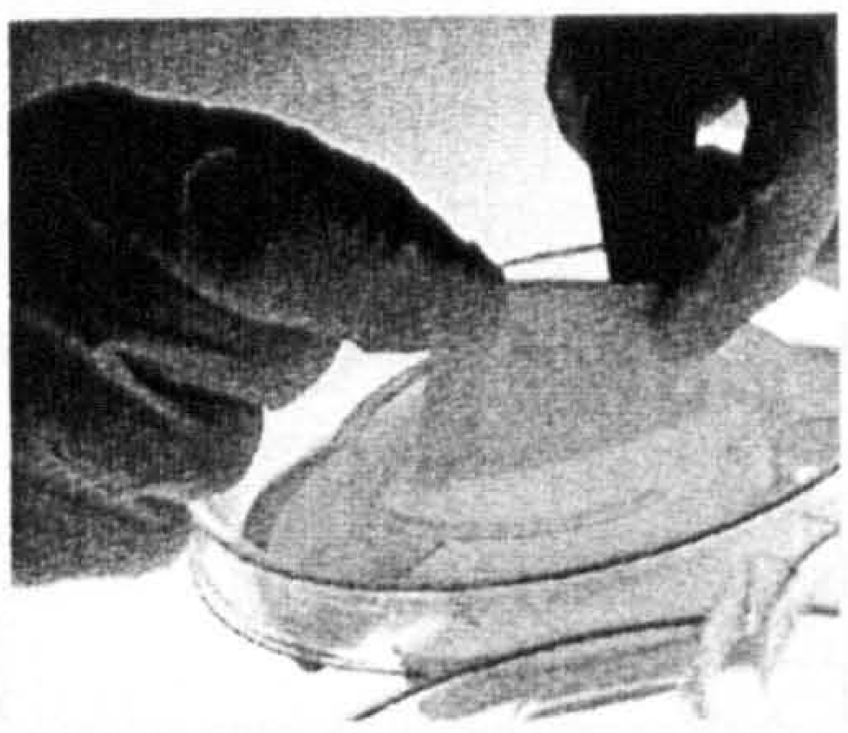
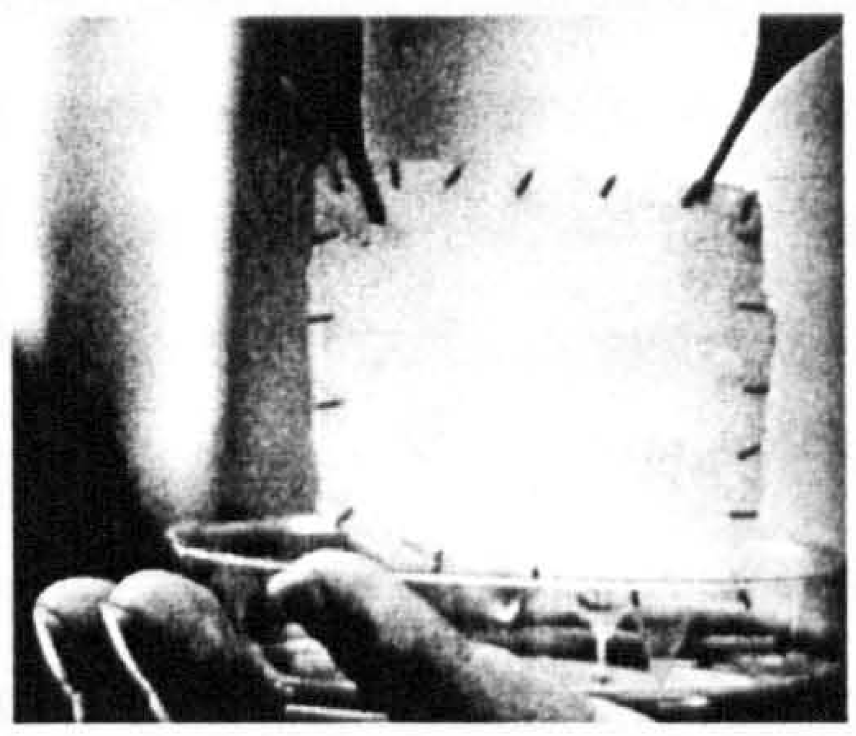
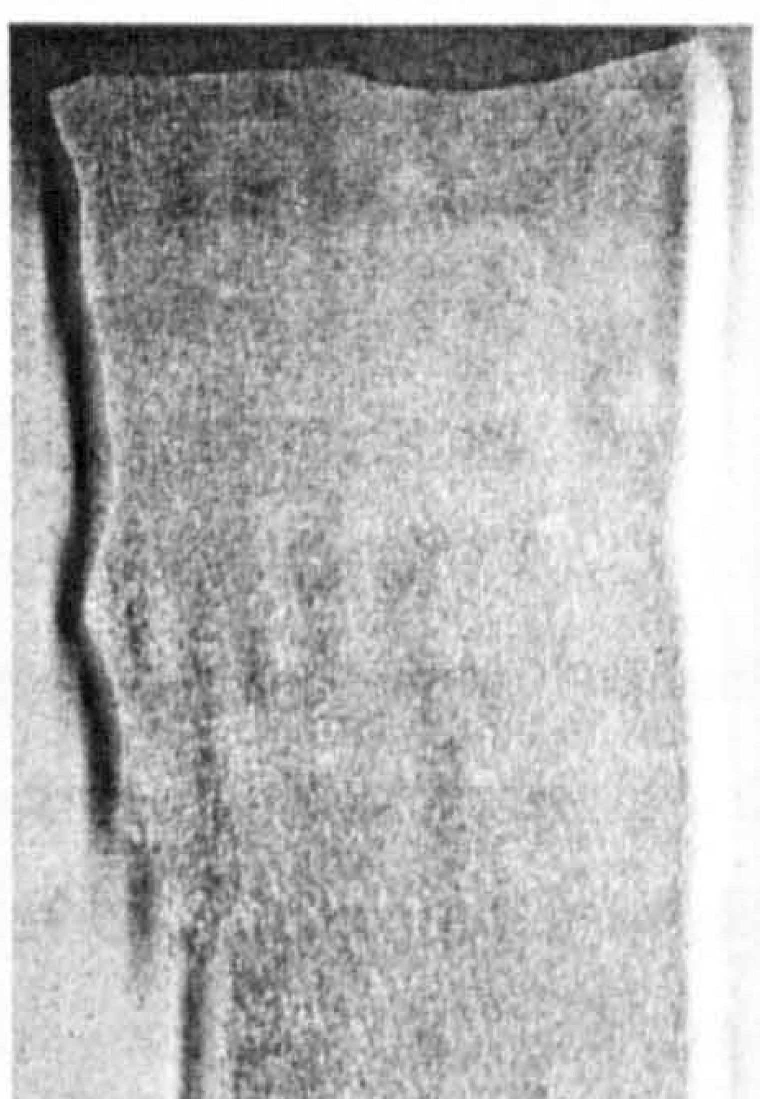




86 Living skin in bioreactor. Apligraf® is a living, two-layer skin product, having both dermis and epidermis.

87 The patient's living skin cells on artificial skin.

86, 87, 88↓, 89↓



88 Artificial skin: this chemically engineered material mimics the cells in the skin upon which new cells can grow.

89 Suprathel Membrane.
The membrane will be used for skin burns. It protects against infections and mechanical treatment but allows exchange of oxygen and water vapour. In clinical tests the membrane also showed a strong reduction in pain. It is made of Polylactid and other absorbable polymers and had been developed by BMOZ e.V (German Center of Excellence for Biomaterials and Organ Replacement). It has been on the market since the beginning of spring 2004.

dermis is particularly needed in severe burns cases such as third degree burns where patients lose more than 50 per cent of their skin layers and in very large or chronic non-healing wound cases. In these situations it is not possible for the skin to heal itself as a normal biological process because the body does not regenerate lost or damaged dermis. Unless replaced by a skin graft, dermis is replaced by the formation of scar tissue. Consequently, the use of an artificial skin transplant becomes compulsory.[16,17]

Though using the patient's own skin for coverage is highly effective in properly prepared wounds it has the drawbacks of hospitalization, immobilization, anaesthesia and pain. Therefore the best solution currently offered by the modern science of biotechnology as an effective alternative to auto grafting (using patient's skin or donor's skin) is an artificial skin transplant. A porous polymer film is placed over the area of damaged skin in order to host new skin (living skin cells cultured in vitro). The edges of these polymers meet and knit with healthy skin. In the future, artificial skin will be used in the treatment of facial disfigurements, acne problems and birth defects, in plastic surgery and even in the regeneration of amputated or severed limbs.

In 2001 New Scientist reported on a new development in tissue culture technique by Modex Therapeutics of Lausanne in Switzerland, which changes the patient's hair into the patient's skin. Called Epidex, the technique uses the stem cells found in hair follicles that can be transformed into skin cells. This technique is thought to replace the painful method of taking skin from another part of the body for grafts or tissue culturing.[18] Furthermore there are also temporary glues and protective finishes, which are available in the form of spray-on dressings to encourage skin growth. 'An electric charge in the spray attracts the solution to the skin and causes the tiny polymer fibers to repel each other, arranging themselves in a regular 'weave".[19]

06.2 SCIENCE FICTION OR FUTURE?

The progress of civilisation is inevitably influenced and directed by technological innovations in all spheres of our life including design. It also makes it increasingly difficult to believe in an authentic and natural human life. Textiles are at the forefront of research by developing high-tech and intelligent fabrics with integrated sensors, nano-particles, plasma treatments and bio-active substances. Technology is changing our lives and more than ever before is being met with suspicion and moral questions. 'Technology cannot be used as a general signifier to the future without acknowledging what that future might be.'[20] Perhaps the best way to demonstrate this is to look at some science-fiction concepts regarding the human body.

Human-like machines, robots and androids represented artificial life in science-fiction fifty years ago. The idea of these creatures is still exploited in today's science-fiction scenarios. As they became more technically elaborate and developed other artificial creatures join the club - the cyborg being a relatively recent addition.

Lately the concept of robots, androids and cyborgs has become a matter of competition with the genetically manipulated human. At the time when future visions of robots were developed it was the epoch of 'hard' sciences such as physics, chemistry and engineering technologies. Currently these concepts no longer correspond to reality - to the actual state of knowledge. In the near future it will not be possible to create a machine, which resembles a human being in its entire complexity. A more realistic future is 'soft' science – biology, gene-technology, biochemistry. In the past few decades these disciplines have proved that they have a powerful potential for innovation and they are increasingly entering public consciousness.

The science-fiction industry is currently occupied with the idea of changing human genetic information employing biotechnology and gene technology in order to construct an 'artificially' 'real' human. The body can be genetically optimised in order to respond to the desired model aesthetically, intellectually or in terms of health. It would appear that no other technology will have the capacity to change the human body in such an effective manner.

Lee M. Silver, an American geneticist, in 'Remaking Eden' talks about this future that is in the making. He describes the population of the United States of America in 2350, which is divided into two classes, the Naturals and the Gene-enriched or simply the GenRich. 'These new classes of society cut across what used to be traditional racial or ethnic lines. [...] But while racial differences have mostly disappeared, another difference has emerged that is sharp and easily defined. It is the difference between those who are genetically enhanced and those who are not.'[21]

New technologies support the scientific and detailed view on and in the human body. In a biomedical sense it has become a living machine – the body separated from the soul and its parts - exchangeable. 'Some scientists refer to the body as a 'project' or 'subject,' a system that can be divided and dissected down to the molecular level.'[22]

The body, which historically was looked at as a bio-social entity with skin being a symbol of this entity, has now obtained a new and scary economical worth, by being valued very highly both as a source of information and as raw material for commercial products. Body parts, blood, cell lines, genes, embryos and tissue are frozen, banked, placed in libraries or repositories, marketed, patented, bought and sold for millions of dollars. 'The value of human body tissue in the biotechnology age – and the potential for profitable patents derived from it – encourages doctors and researchers to think about people differently.'[23] In their book 'Body Bazaar' Andrews & Nelki are saying: 'some think of it [body] as a sacred temple, others as a biomedical factory' and they continue explaining that the increasing use of bodily materials in current biomedical practices introduces fundamental and complex dilemmas. The extraction of body tissue contributes to scientific research but it also interferes with body boundaries, imposing on individual autonomy if used without consent.

The above discussed issues were relevant for the inclusion into my thesis for two reasons. Firstly, because at the early stages of my project I was using biological materials (skin specimens and negative skin casts) for microscopical imaging. Secondly, because parallels can be drawn between the human body and textiles, as both are currently at the forefront of scientific research. Thirdly, because in biomedical terms textiles are merging with the body as they are being engineered to replace almost any body part, including the skin. Therefore the question on how (bio)technology is used becomes particularly important during my research. However, for my investigations I was obtaining each donor's consent to cast negative imprints of their skin and to use them for research purposes. The biological skin tissue samples were borrowed from the Beauty Science Department, LCF. None of the latter were prepared specially for my research, as before and after my experiments these particular specimens were used for educational purposes.

06.3 ARTISTS COMMENT ON SCIENCE

Scientific dissection was perhaps the most crucial innovation in the development of biomedical ideas concerning the human body.[24] It was originally the artists who pioneered investigations of the human body interior. These studies occurred around the beginning of the 16th century, at a time when the church began to relax its prohibitions on anatomical dissections. Breaking with medieval tradition, dissections were carried out by artists and anatomists (Fig 90). Anatomically correct depiction of the human body in the visual arts was a direct consequence of these experiments.[25]

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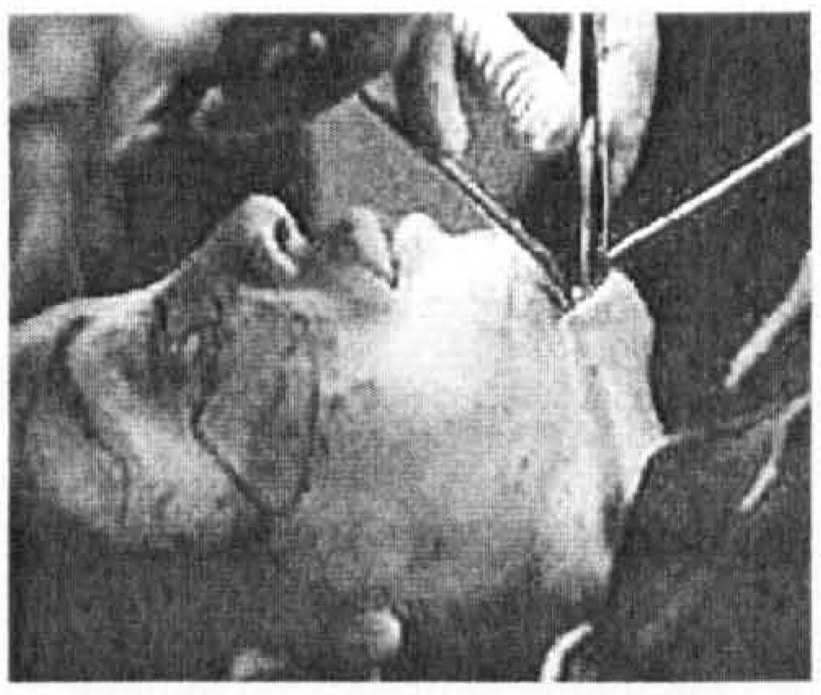

92 French performance artist Orlan undergoing one of her self modification sessions. She uses a surgeon's scalpel the same way as a painter uses a brush in order to comment on the contemporary mechanisms of the recreation of the body.

93 Orlan. Computer manipulated photographic image.

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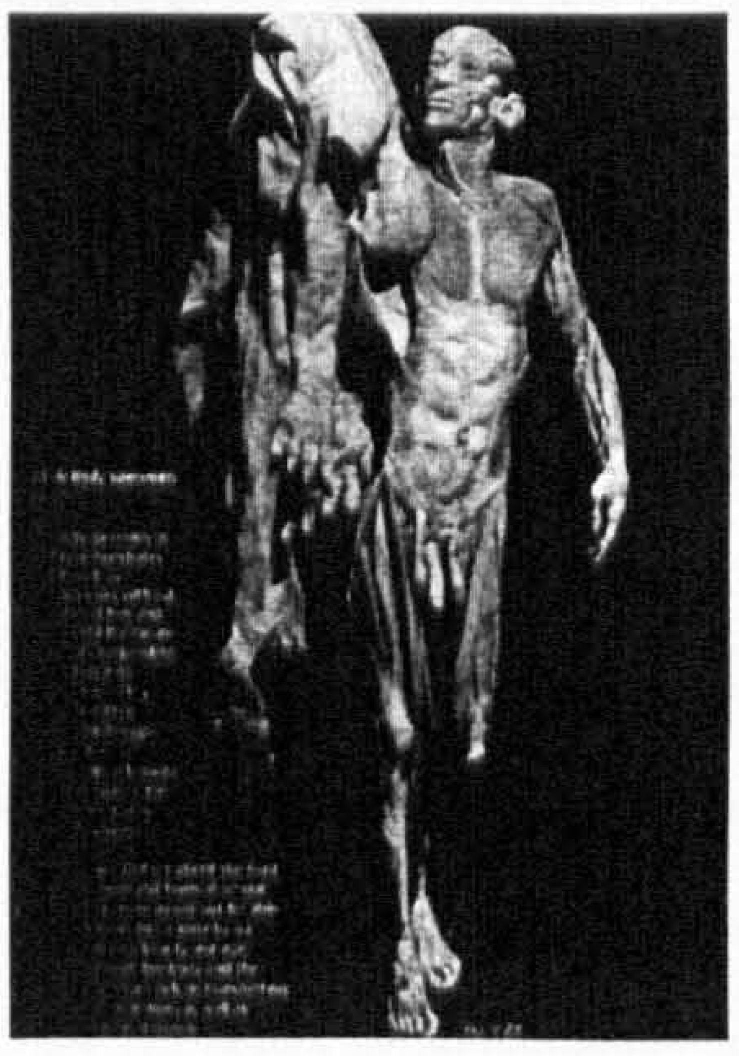
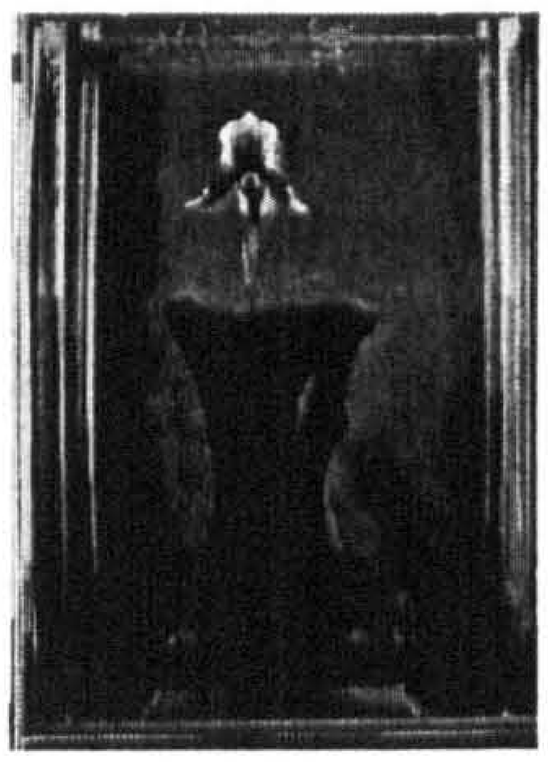


94 A whole body specimen in a life-like pose with skin. Anatomy art by Prof. Gunther von Hagen.

95 Historia de la composicion del cuerpo humano (1556) by Juan Valverde de Hamusco.

94, 95



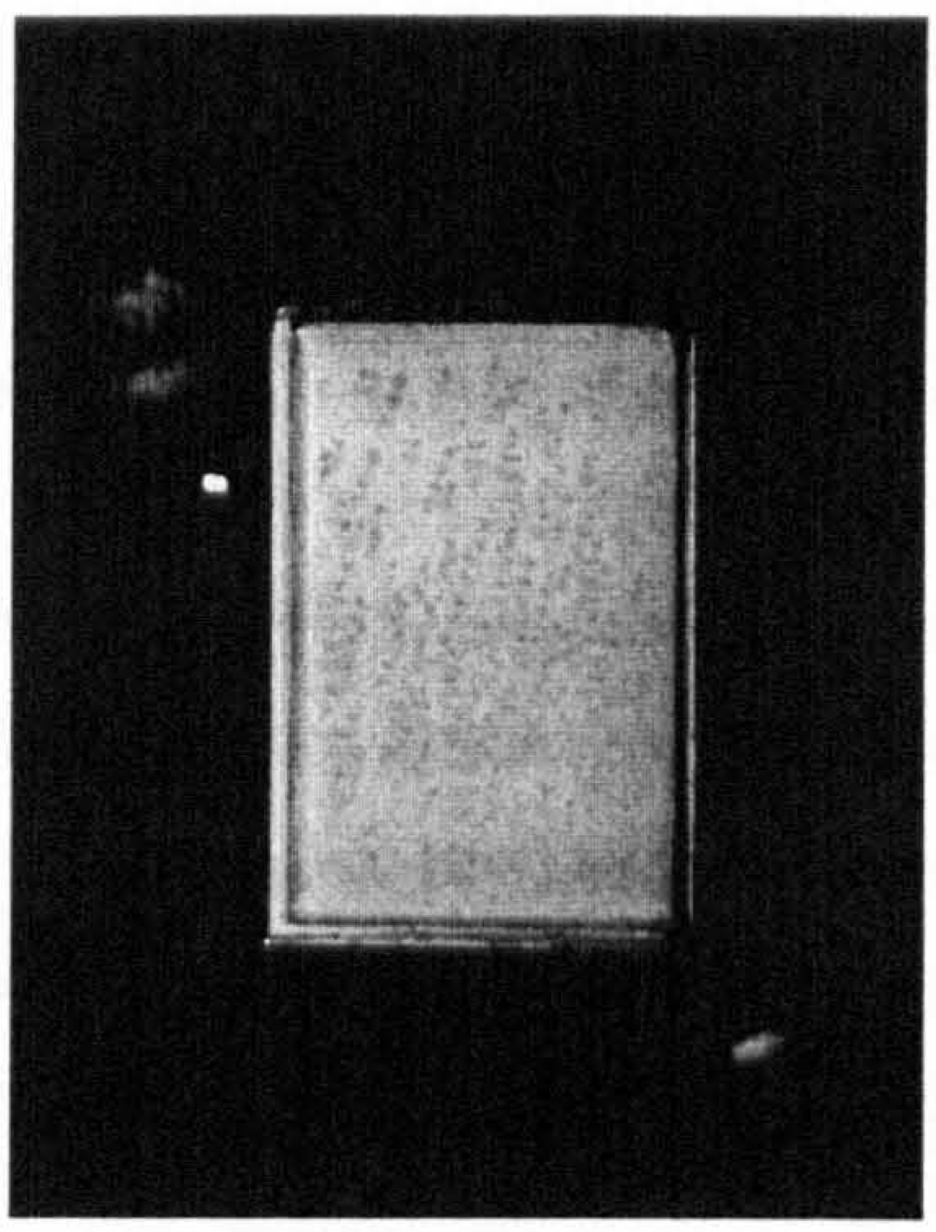
96 Marc Quinn
Reincarnate, 1999.

Stainless steel, glass, frozen silicon, orchids and refrigeration equipment.

97 Marc Quinn
Lucas, 2001.

Placenta, stainless steel, glass, frozen silicon, perspex, refrigeration equipment.

96, 97



98 Marc Quinn
A Genomic Portrait: Sir John Sulston, 2001

Sir John Sulston is reflected in the stainless steel frame of his 'DNA image'. The frame is representative of a sterile scientific environment.

98

The most well-known artist and scientist of that time, Leonardo da Vinci (1452-1519), while performing anatomical dissections, was recording the structures he saw in drawings and sketches (Fig. 91). These and other artist's illustrations supported by the growing power of the printing press, made a significant contribution to communicating information about the body and to society's understanding of anatomy.[26]

Today contemporary artists are again becoming 'research artists'.[27] There is an increasing fascination with new biomedical research, which is already starting to shape the 21st century's scientific context and as a consequence, society itself. In order to highlight this trend the following exhibitions must be mentioned: 'Spectacular Bodies' at the Hayward Gallery in London, 2000; 'Growth Form: Biomedical Images – Awards and Interpretations', at The Wellcome Trust, Two10 Gallery in London, 2001; 'Körperwelten – Fascination beneath the Surface' at the Ost-Bahnhof in Berlin, 2001 - the same exposition under the name 'Anatomy Art' was showed in London in 2002; 'Mental' by Helen Storey at the ICA gallery in London, 2001, 'Metamorphing: Transformation in Science, Art and Mythology' at the V&A Museum in 2003 and others.

06.3.1 HUMAN TISSUE IN ART

Fascination with Biological Materials

The human body has long been a source of immense fascination for artists. Models have posed in artists' studios for centuries and when living models were not available, artists turned to hospitals or morgues and did their sketches there. Artists in different periods used cadavers and dissections to express 'the horror, the pathos, the vulnerability or the factuality of the materialized body.'[28]

Human body tissue is crucial to health care, however, in the current art context it has also become a medium for artists who are using human hair, flesh and DNA for their creative practices. They have discovered ways to sculpt in blood or placenta and to plastinate skin and 'some are using this medium to comment on the changing meanings of the body in the biotechnology age.'[29] However, Andrews & Nelki remind us that using the human body for art and display can often be controversial. 'Underlying the disputes are questions similar to those raised by the use of body tissue in research and forensic testing: How are the bodies obtained? Whose consent, if any, is necessary? What values are at stake in decisions about displaying and working with the body?'[30]

Through modern medical means, using a surgeon's scalpel the same way as a painter uses a brush, French performance artist Orlan transforms her own body, which becomes a work of art in the process (Fig. 92, 93). Her body serves as sculptural material and undergoes the creative process in a hospital operating room, symbolising her own rebirth and directly linking with the idea of liberating herself from the constrains of being a mere mortal. She attempts to ignore the tyranny of nature and she herself refers to her fight against God with the intention of taking decisions and creation into her own hands.

Orlan's material self-hybridisation is to be seen as a conceptual statement about our era. She shows how the conception of pure visuality is built upon real flesh, the flesh of women abandoning their own will or pleasure. Malgorzata Listewics, for instance, writes that Orlan's performances not only constitute a commentary on the contemporary mechanisms of the recreation of the body, but 'also enter into an ironic dialogue with the modernist worship of the artist – as a male subject. Demonstrating her wounds to the world, Orlan clearly alludes to the stardom of Warhol and the shamanism of Beuys. She focuses the signals coming from the male world in herself and gives them a new, ironic shape.[31]

'Orlan acts not only on her body, but upon her body, as an instance of a series. What happens is not just surgery. What happens is abstraction in the sense that cosmetic surgery always moves from the concrete to the abstract, from what exists to an image.'[32] Orlan is the first artist who has chosen aesthetic surgery as her medium. Her purpose is to gain true metamorphosis. The project 'The Reincarnation of Saint Orlan' consisted of a series of plastic surgery sessions, starting on May 1987 whereby the artist sought to embody references of the aesthetic ideal as represented in Western art. 'Orlan now literally has the chin of Botticelli's Venus, the eyes of a Fontainbleau Diana, the lips of Gustave Moreau's Europa, the nose of Jean-Léon Gérôme's Psyche and the brows of Leonardo's Mona Lisa.'[33] Through bloody manipulations, she has changed her appearance and obtained a new identity.

During the winter of 2000 at the Osthahnhof in Berlin an extraordinary and controversial exhibition called 'Körperwelten – Fascination beneath the Surface'[34] was displayed and later the same exposition was shown in London under the name 'Anatomy Art', achieving a lot of public interest in both capitals. Around two hundred body parts and life-size figures were publically exhibited. These were not exactly sculptures nor conventional body casts. They were real human corpses or parts of real bodies, pathological specimens, including abnormal human foetuses, preserved and prepared through an embalming process called plastination.

The author and inventor of plastination, German Professor Gunther von Hagens who is also a physician and anatomy lecturer at the University of Heidelberg, himself interprets his figures as 'anatomical artwork.' In the catalogue he refers to the 16th century 'when artistic talent and anatomical knowledge were combined' and when 'the most artistic works in the history of anatomy were created' (Fig. 95). He claims to be continuing this tradition by preserving 'natural anatomical specimens in a durable, realistic and aesthetic manner for instructional and research purposes as well as for general education.'[35]

In the exhibition 'Körperwelten' whole-body specimens were displayed in various poses with names such as 'The Runner', 'The Swordsman' or 'The Chess Player' ('The Thinker') with the intention of demonstrating in detail the body parts responsible for each different activity. Another figure 'Posed Whole-Body Specimen with Skin' has all the muscles and bones exposed and his flayed skin draped over his arm like a garment (Fig. 94). In the commentary on this figure von Hagens writes: 'The whole-body specimen [...] demonstrates on the one hand how vulnerable man looks without the skin to protect him, and on the other hand the nature of the skin as an independent organ when there is no longer a body inside.'[36]

British conceptual artist Marc Quinn, who often explores the relationship between the two disciplines of art and science is perhaps best known for casting his own head in blood. In 1991 he created Self, in which he sculptured a self-portrait using nine litres of his own blood. The head has to be kept refrigerated in a glass cabinet. Every five years he creates a new Self using fresh blood and a new cast. Without refrigeration his work would melt. Later he produced less controversial art pieces embodying similar ideas. For example at the 'Spectacular Bodies' exhibition (Hayward Gallery in London, 2000) he showed frozen flowers in a refrigerated glass cabinet, representing in this way the fragile nature of the human body and the ephemerality of our lives (Fig. 96).

Lately Marc Quinn has made use of modern technologies which allow the body to serve as the basis for less literal representations. In September 2001 he unveiled 'A Genomic Portrait: Sir John Sulton' which is a collaboration between the artist and Sir Sulton - an invaluable contributor to the Human Genome Project (Fig. 98). Quinn used the actual scientific process from Sir Sulton's work to create the portrait. 'The portrait [...] was created using standard methods of DNA cloning. They [Sulton and Quinn] extracted DNA from a sample of Sulton's sperm, which was then replicated in an agar culture, resulting in transparent colonies of bacteria, each grown from a single cell containing part of the instructions to make another John Sulton.'[37]

The artist himself comments on his work: 'It is a portrait which is not just about the outside but the inside as well, and although it is the first abstract image in the NPG [National Portrait Gallery], it's their most realistic by definition.'[38]

CHAPTER 07 ::

TEXTILES - THE ENGINEERED SECOND SKIN AND THIRD SKIN

07 TEXTILES – THE ENGINEERED SECOND SKIN

'Design reflects and shapes our understanding of the world; it is both symptom and cure. As a practice embedded in the fabric of technology and commerce, design responds critically to the very culture it serves to replicate and extend.'[1] ***Ellen Lupton, curator at the Cooper-Hewitt, National Design Museum***

As discussed in the previous chapter, overall rapid developments in science and medicine are invigorated by the new technologies and vice versa. The discoveries in the field of material science and biotechnology are inevitably reflected in art and design – from products, fashion, interiors, architecture to media. Innovations in design are often linked with the utilisation of new materials. Many materials that were originally developed for technological applications have specific visual or tactile qualities in addition to their functional properties which make them attractive for design applications.[2]

Surfaces, membranes or industrial skins have been the fascination in design and architecture for some time now. They are flexible, translucent, functional, adaptive, responsive, intelligent and highly complex – indeed, like biological skin itself. Due to specialised material properties these systems can respond to pressure, light, fluids, heat, electric or mechanic stimuli. They are designed to interact with people and environment. 'The primacy of the skeleton has given way to the primacy of skin. Surfaces have acquired depth, becoming dense, complex substances equipped with their own identities and behaviour.'[3] The elaborate skins of designed objects, buildings and garments already now have the appropriate intelligence to respond to input from users and the environment. Examples of smart skins include such design products as ELEKTEX SOFT KEYBOARD (2001), SOUNDWAVE, BASIC HOUSE (1999) and CHROMZONE (1999).

ELEKTEX SOFT KEYBOARD is a prototype by the design company IDEO (Fig. 99). Designer Sam Hecht has been using ElekTex, a conductive fabric whose entire surface can sense the location and pressure of human touch, serving as an active and intelligent surface. The fabric skin is flexible, washable and programmable, it is a sensing and switching system that translates electronic impulses into digital data.[4]

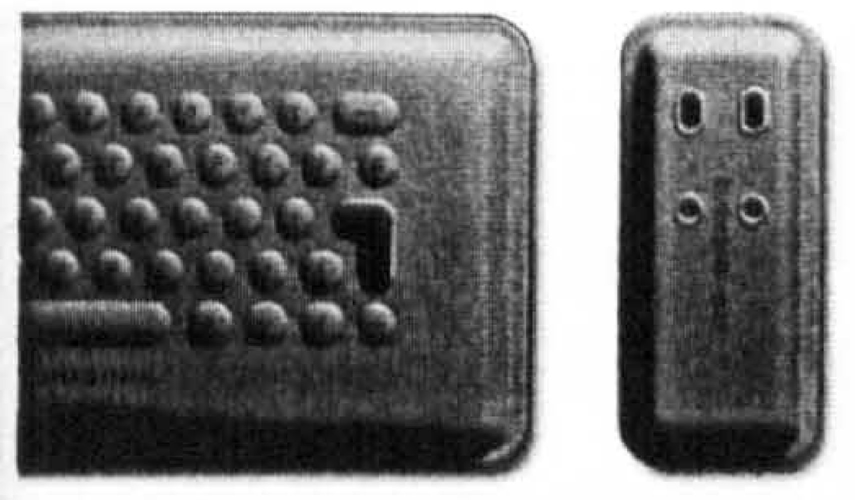
SOUNDWAVE is a sound absorbent wall panel made of moulded polyester fibre by the Swedish company SNOWCRASH (Fig. 100, 101). It can be used for interior walls, suspended screens, free-standing space dividers and as a backdrop for plasma screens. Usually the sound absorbent materials used in interiors are not particularly visually pleasing. 'SOUNDWAVE, however, combines functionality and aesthetics to make acoustic control a visible dimension of environmental design.'[5]

BASIC HOUSE is a concept by Spanish designer Martin Ruiz de Azua who has created an inflatable tent for illegal immigrants using a metallised polyester foil which is normally a standard insulating material for aeroplanes (Fig. 102 - 104). Because of the material properties, this reversible shelter is particularly resourceful, with minimum volume when folded and maximum insulation. It protects against heat and cold, it is lightweight (200g) and thin (13 microns) but strong and reflective. 'The shiny gold side reflects 90 per cent of the sun's rays; worn with the gold side out BASIC HOUSE ventilates the body. The silver side keeps the user dry and warm, while maintaining body temperature.'[6,7]

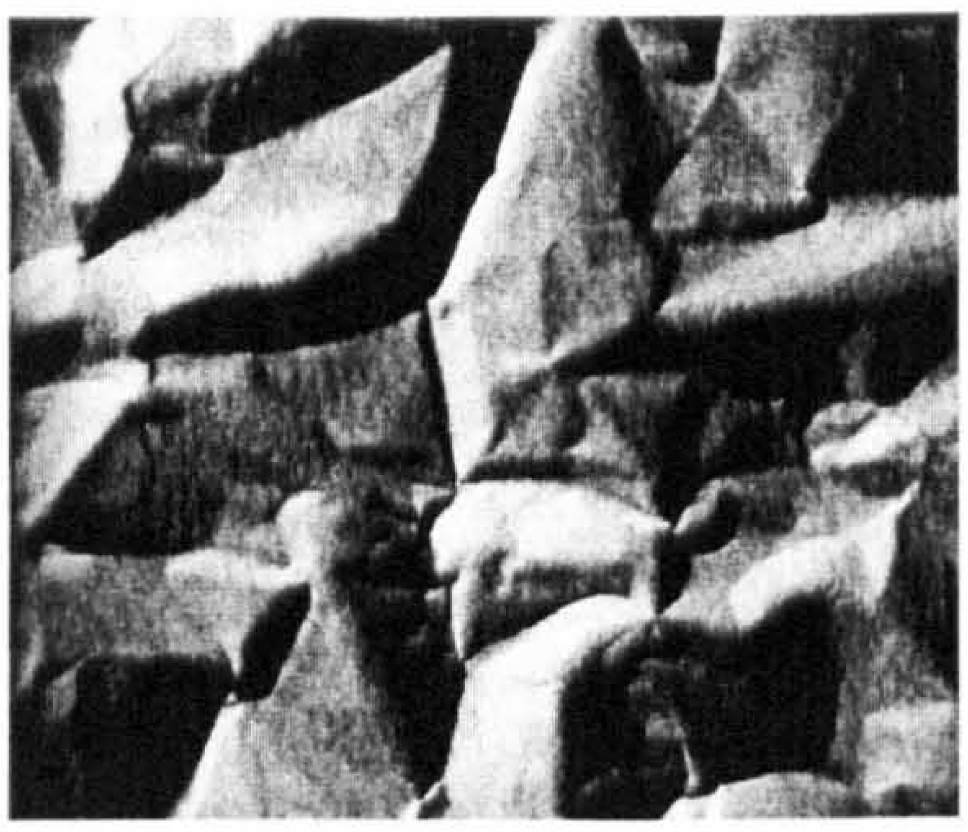
CHROMZONE by industrial designer Karim Rashid from New York is a table with a heat sensitive polymer top (Fig. 106). The surface of the table changes colour in response to heat from hands and hot dishes, becoming a visual index of the everyday rituals performed on it.[8] A similar concept has been published by Japanese design team FLASK that uses thermochromic paint, which changes colour at 36°C or above, for the finish of their furniture.[9] (Fig. 105)

07.1 FUNCTIONAL TEXTILES

Besides the historical functions of textiles and garments as supplementary skin and shelter, there are now additional functions incorporated into contemporary textile products. Innovation in the textile industry does not simply mean improvement of textile processes employed for many centuries. In the current context innovation means integration of new (sometimes non-textile) technologies such as nano-technologies, space technologies or communication technologies in order to engineer and develop high-tech products. 'Development is being driven by industrial applications. There is an increasing need for fabrics which can combine strength and functionality with lightness in weight and competitive costing.'[10] There already exist a wide range of specialised technical fabrics which are classified into groups according to their function and end application: Medtech, Hometech, Mobiltech, Indutech, Agrotech, Buildtech, Clothtech, Geotech, Sporttech, Protech and others.[11]



99 ElekTex Soft Keyboard, 2001
Keyboard; pressure formed ElekTex (conductive textile) on siliconised foam, rubberised silicone and electronic components.
Designer: Sam Hecht, IDEO.
Manufacturer: ElectroTextiles.



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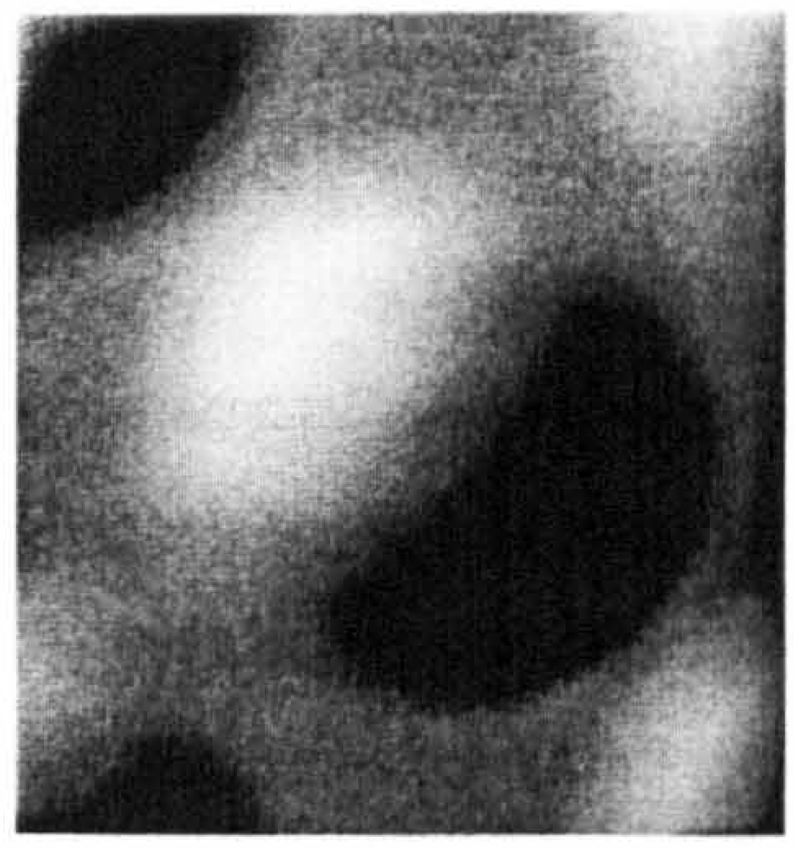

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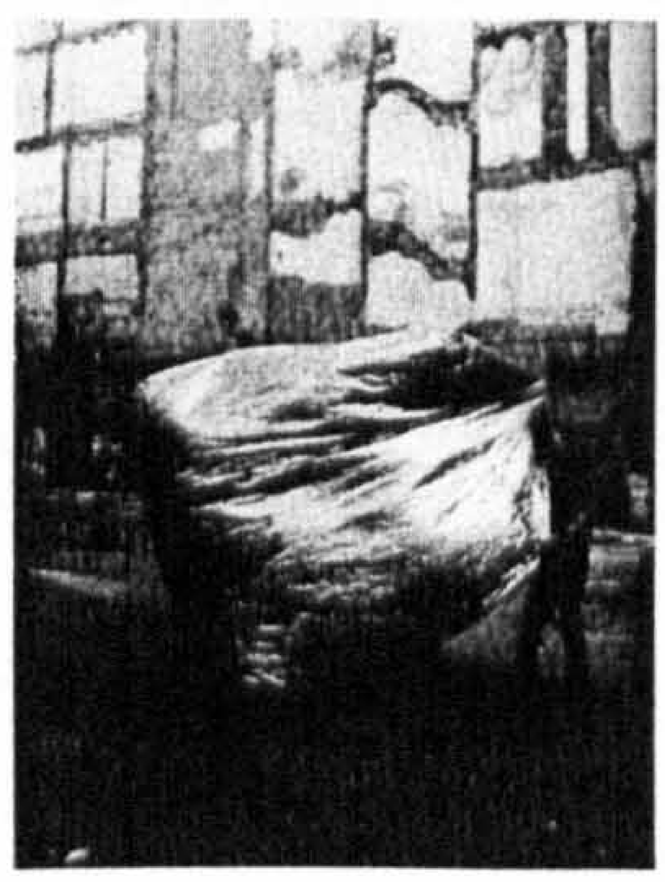

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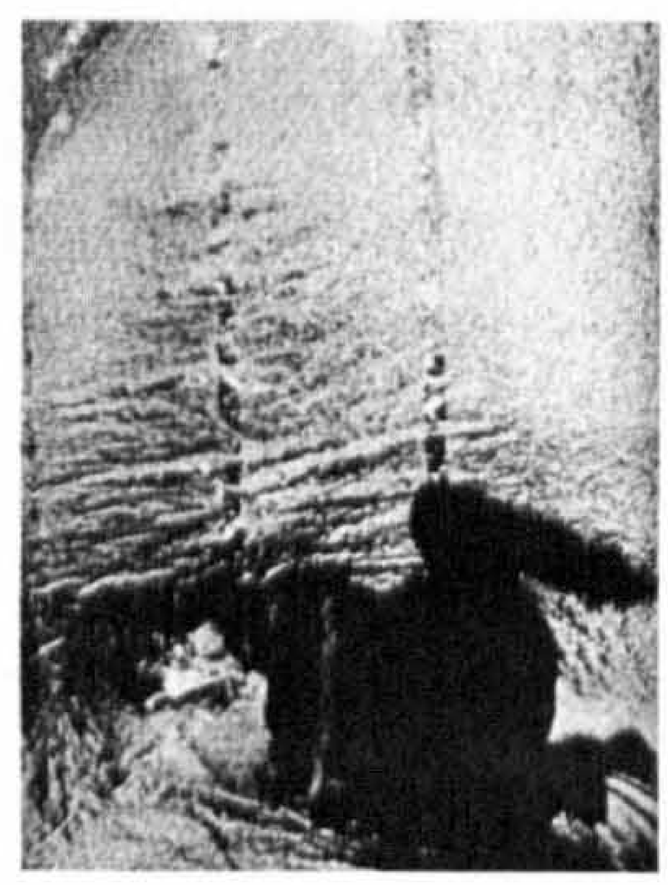

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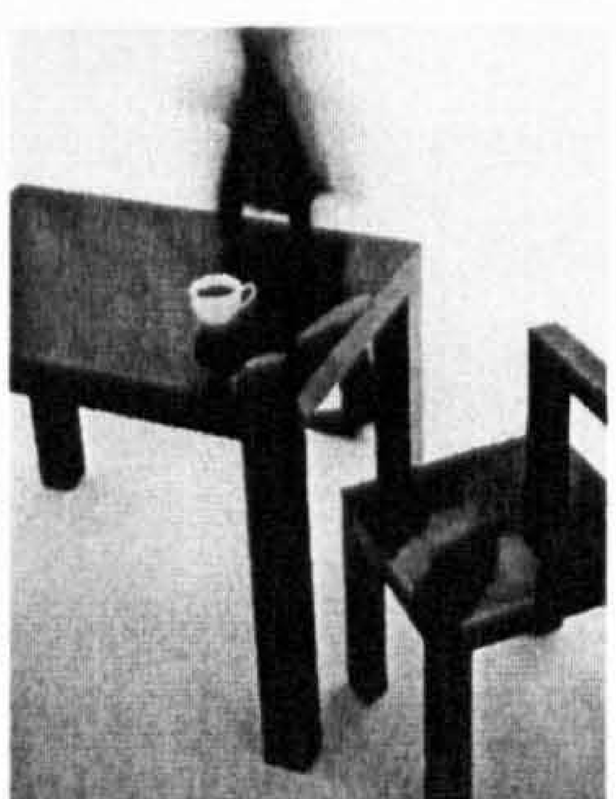

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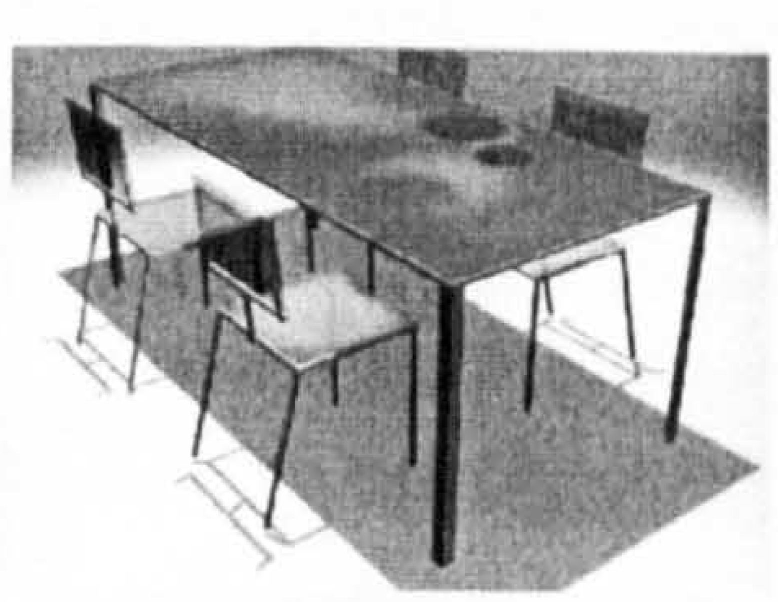

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100, 101 SOUNDWAVE is a sound absorbent wall panel made of moulded polyester fibre by the swedish company Snowcrash. they are versatile tactile and easy to clean.

102, 103, 104 Basic Home, 1999.

Minimal volume, maximal insulation thanks to the metallised polyester foil.

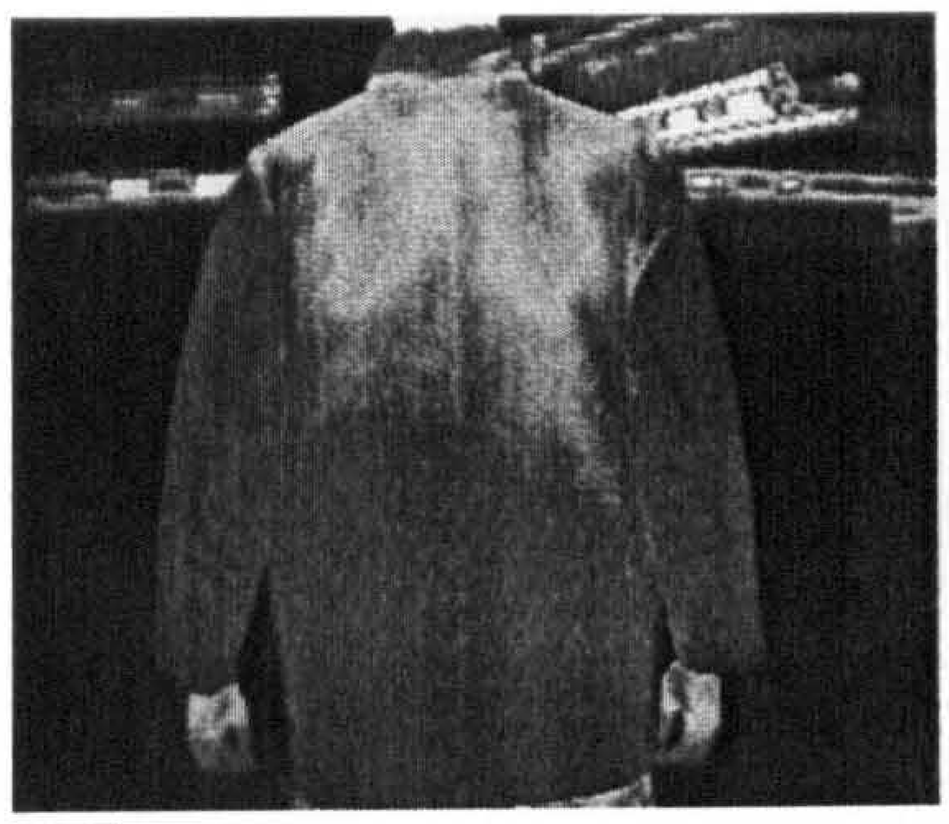
Designer: Martin Ruiz de Azua.

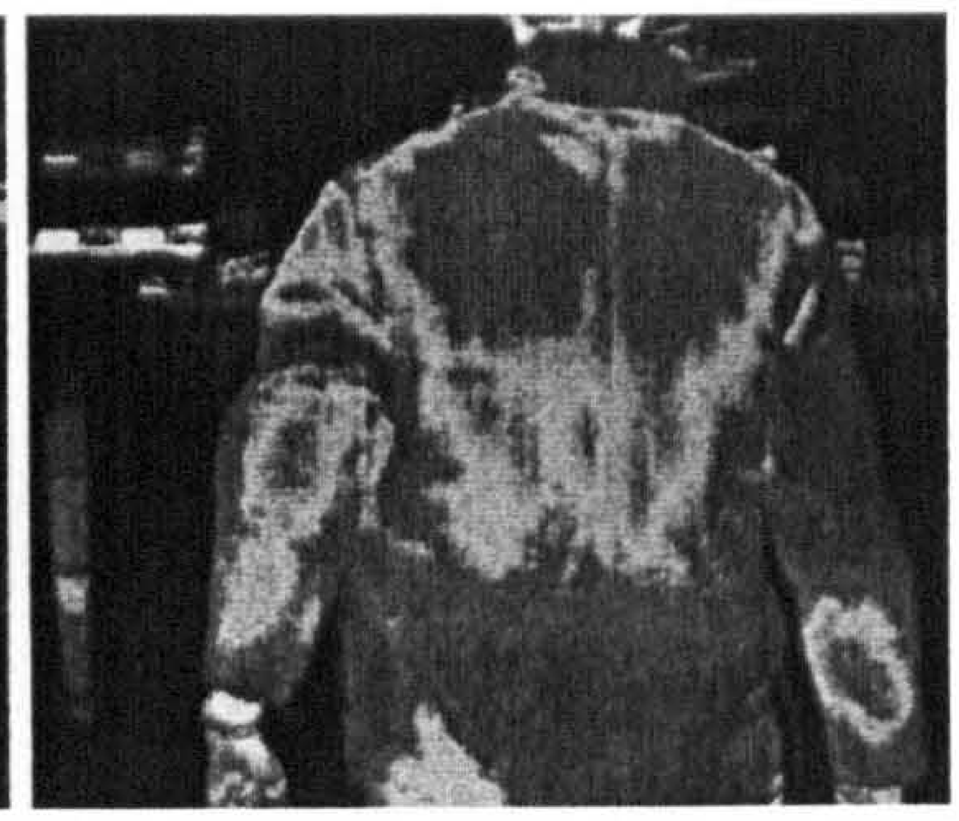
105 Japanese design team FLASK uses paint with thermochromatic pigments as an experimental finish for furniture.

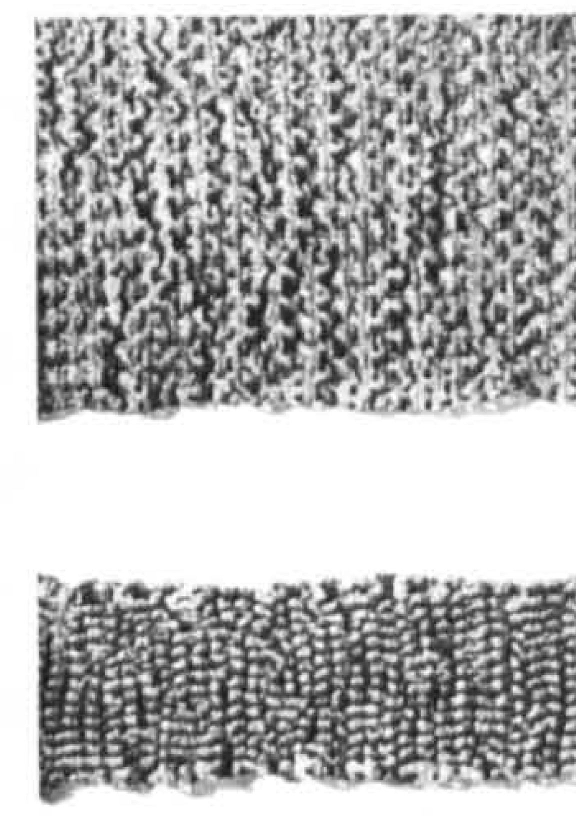
106 Chromazone, 1999.

Table, heat sensitive polymer, and steel square tubing.

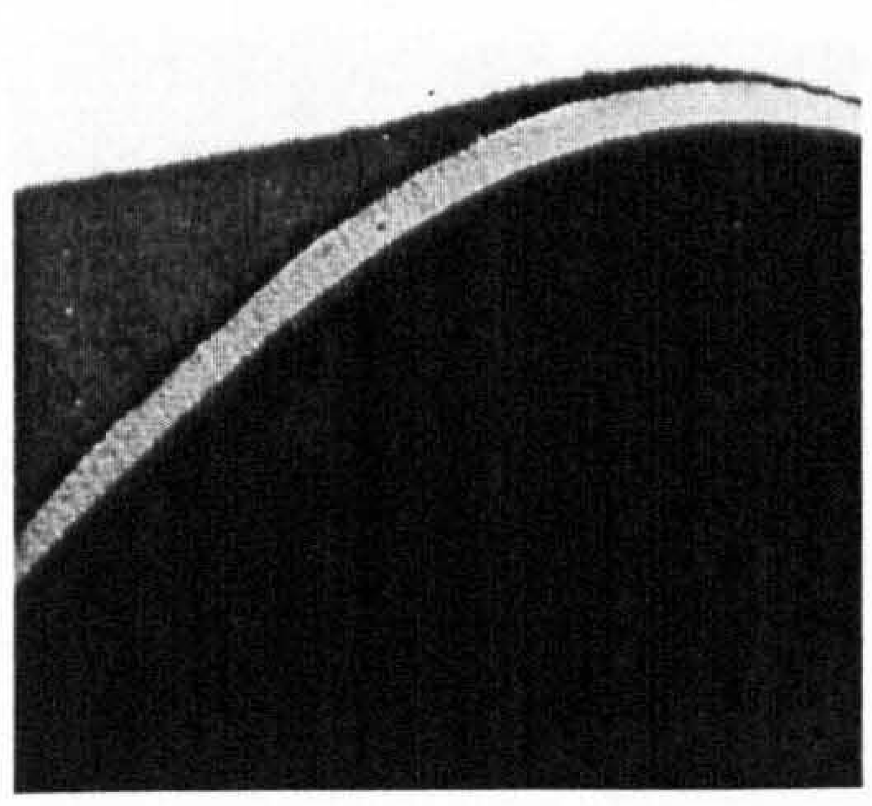
Design: Karim Rashid.
Manufacturer: Totem.







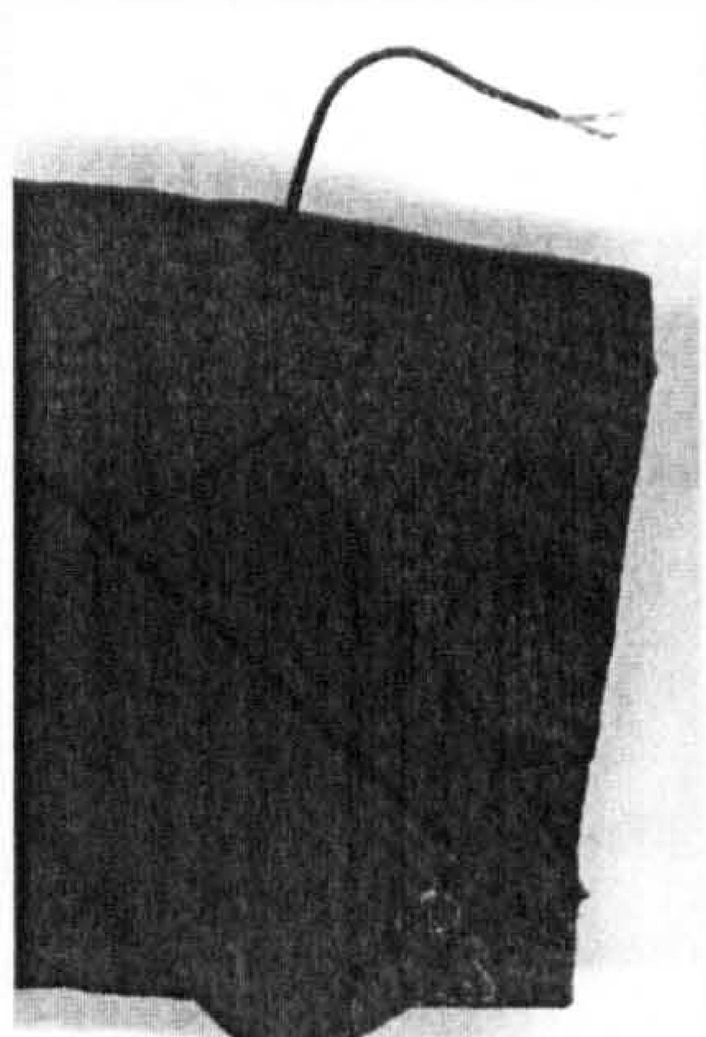
107 108 109



107, 108 Climate control fabric featuring PCM-filled microcapsules by Schoeller. PCM fabrics can store heat and emit it later, to protect the body from excessive cooling. The difference between heat storage in a jacket with and without PCM is visible after a period of 45 minutes. The illustrations are the result of thermal photography.

109 Textiles with shape memory alloys that are variable in form. Flexible, lightweight and easy to process. Designer: Marielle Leenders.

110 111



110 PCM. Schoeller-ComforTemp is produced by Schoeller and ComforTemp is a registered trademark of Frisby Technologies. The three-layered structure of the textile can clearly be seen.

111 Anti-microbial fibres with a coating of 15 per cent silver. It is antimicrobial, antistatic, anti-odour, therapeutic, nonallergic, chemical free and it transfers heat.

112 This woven heating textile is made of polypropylene/polyester yarn and stainless steel. It is flexible, heats quickly, has a folding resistance of more than 2000 folds and it can be pleated.

113 Photochromatic coatings are liquid and transparent materials that can be sprayed or printed onto various surfaces. They darken with increasing light intensity or change colour the moment they are exposed to UVA or UVB rays.

112 113

Material scientists are working on optimised material properties which offer an extensive spectrum of new applications and multiple functions. There is an inevitable movement taking place in the textiles sector towards an actively planned and developed textile product which has to support, comfort and improve our busy lifestyles. Market research specialists believe that a successful future for the European textile industry lies not in an increasing reduction of production costs, but in so-called intelligent products. 'Many future textile products will require specialized engineering knowledge to make them. For example, the future design and production of clothes may become as complex a process as automotive design, requiring a design approach much more like that of industrial design or engineering.'[12]

Put in simple terms 'intelligent textiles represent the next generation of fibres, fabrics and articles produced from them. They can be described as textile materials that think for themselves. This means that they may keep us warm in cold environments or cool in hot environments, providing us with considerable convenience and even fun in our normal day-to-day lives, for example through the incorporation of electronic devices or special colour effects.'[13] Smart materials, systems and structures can sense changes in the environment, such as variations in temperature, light or pressure and can interact with the surroundings or the user in various ways. Examples include antibacterial and antiviral fabrics (Fig.111), food labels that change colour if the product is stored at the wrong temperature, sportswear with integrated thermo-regulating systems (Fig.107,108), shape memory fabrics (Fig.109) that help clothes regain their shape after washing and crumpling or flexible textile membranes which are embedded with digital and mechanical networks such as computer keyboards that can be rolled up.

According to the outcome of a survey undertaken by researchers at Tampere University in Finland, the most important smart materials for intelligent textile products at present are phase change materials (Fig.110), shape memory materials (Fig.109), chromic materials (Fig.113) and conductive materials (Fig.112).[14] These materials, in the form of fibres, microcapsules, coatings or dyes can be implemented within the structure of the fabric, or applied to its surface thereby adding specialised properties and characteristics to them.

A great deal of innovation comes from the military and aerospace industries, where extensive research has been undertaken into material properties and applications, albeit with strictly circumscribed objectives. Numerous technologies and concepts are being adapted for use in the civil sector, particularly for workwear, sportswear and for specialised medical applications, where the human body is subject to extreme conditions. One such example is the Smart T-shirt, initially developed for military applications and funded by the US Defence Advanced Research Projects Agency (Fig.114,115).

The original intention was to develop a health-monitoring garment with a complex grid of fibre optic sensors that would help the medics to locate the injury of the marine. 'The Smart Shirt incorporates a 'Wearable Motherboard' which is essentially a fabric embedded with sensors that can receive and transmit information between the wearer and garment. This is used alongside a specially developed Application Programming Interface (API), open architecture hardware and software, which then relays information from the garment to a remote (wireless) location such as the medical triage unit.'[15] Now the Smart Shirt concept has been adopted by the company Sensatex Inc, which is currently working on the development of this technology for various commercial products including child monitoring and care for the elderly to prevent life-threatening or other emergency situations.

7.2 BIOMIMETIC DESIGN

Co-operation, partnership and exchange of knowledge and information between diverse disciplines has become essential for the development of new and improved functional products. The potential of the future for both science and design lies in a multidisciplinary approach. Disciplines are merging, boundaries are melting and 'many [...] technologies are not significant when looked at in isolation, but become of critical importance when coupled with other technologies.[16]

One such arena, where an interdisciplinary approach is the starting point, is the emerging research field of biomimetics, which combines the expertise of zoologists, biologists, engineers, chemists and designers. 'The main reason for this is that biological structures are often multifunctional, in the sense that they often perform more than one task.'[17] One of its pioneers, a professor at the Bath University Julian Vincent, describes biomimetics as ' the abstraction of good design from nature' where the degree of the abstraction is more a personal decision. He continues: 'It [biomimetics] means just what I choose to it mean - neither more or less.'[18] Biomimetics is not about imitation or copying nature at any cost, but the sensible selection of observed properties or mechanisms and their development into sophisticated artificial systems and products.[19]

There are many lessons to be learned from nature in order to develop truly intelligent systems. As the German equivalent of British biomimetics guru J. Vincent, professor Verner Nachtigal, notes: 'there is not a single detail, which is simply beautiful but useless in the organic world. Everything has its function and is well designed. The main principle in nature is to save energy.'[20] 'A similar situation obtains with engineering, where cost is usually the most significant parameter. It seems likely, then, that ideas from nature, suitably interpreted and implemented, could improve the energy efficiency of our engineering at many levels.'[21] George Jeronimidis, professor of Biomimetics at Reading University, points out another biomimetic lesson arguing that the base materials in nature are very few - far fewer than what is available to the engineering community. None of them is particularly strong or tough and cannot be specified as 'high performance materials'. 'They are successful not so much because of what they are but because of the way in which they are put together.'[22] In other words, a successful product design does not necessary require expensive or highly complex materials.

A creative approach to engineering and designing is also crucial in the textiles field when developing new fabrics with an added function. The principles of biomimetics proved to be really fruitful when developing SPEEDO'S FASTSKIN bodysuit, based on the analogy of the microscopic structure of shark skin (Fig.116, 117). Its skin is covered with a series of tiny ridges which considerably reduce the water resistance around the shark. SPEEDO'S swimsuit design mimics this phenomenon of nature and was first used in the Sydney Olympic games.[23]

Another example of a successful biomimetic approach in engineering and designing sportswear is O'Neill's neoprene ANIMAL wetsuit, which, as the name suggests, has an animal appearance (Fig.118). It is important for surfers to have freedom of movement and therefore the garment has to provide flexibility, 'particularly around elbow and knee joints, without loss of thermal insulation.'[24] This is not an easy task. O'Neill introduced his Expansion System - a moulding system which produces 'bellows-like sections for use in high-flex areas forming accordion pleats for ease of movement.' This technologically innovative aspect is basically an imitation of typical mechanical properties of skin - the most intelligent packaging material in the world, being flexible and adjusted to master different functions on different body parts.

The Centre for Biomimetics at The University of Reading is conducting research on the operating principle of pine cones opening and closing as well as the insulation mechanisms of penguin skin in order to engineer smart fabrics for responsive clothing.[25]

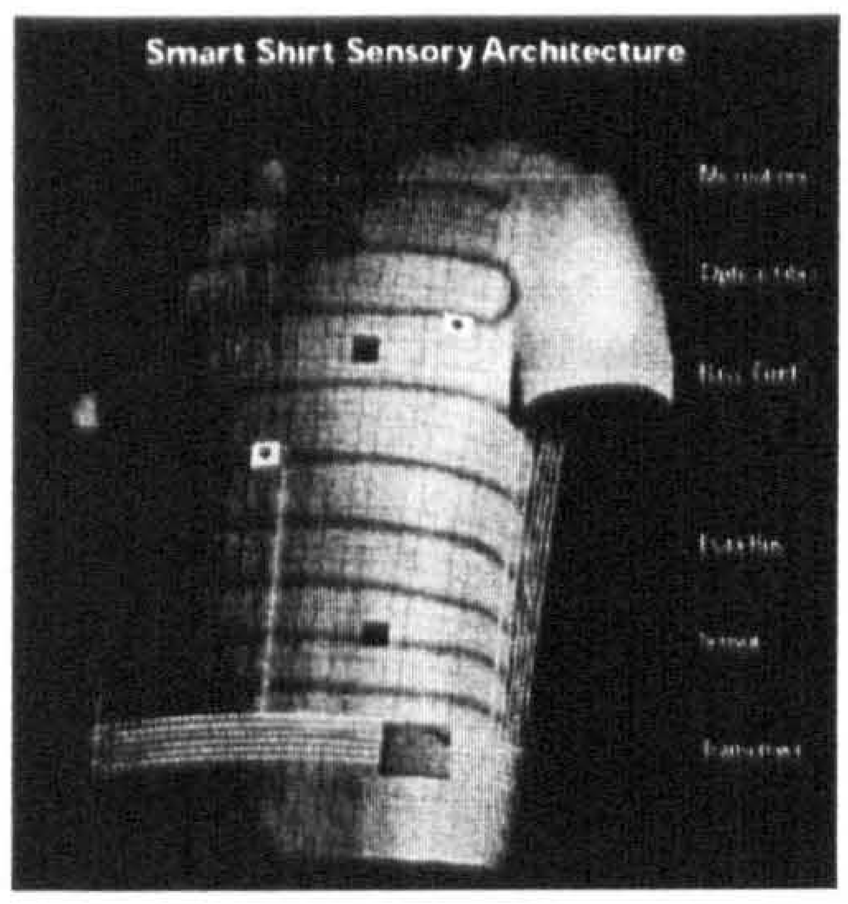
The aim is to produce a garment 'with transpirational properties based on the state of activity of the wearer' which would be particularly useful in areas with extensively fluctuating temperatures during the cycles of day and night. 'This is of particular interest in the defence industry, meaning that the minimum layers of clothing need to be worn at all times.'[26]

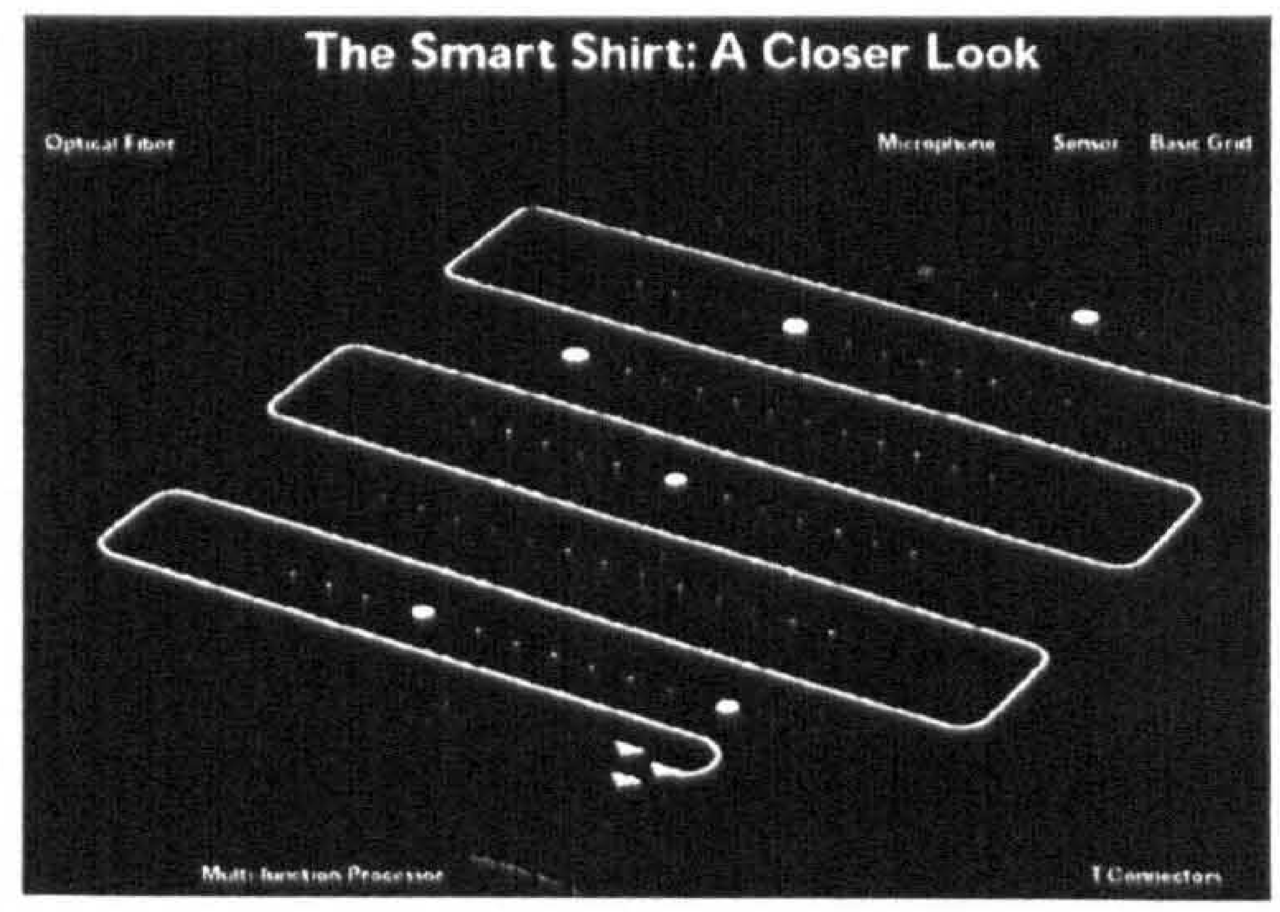
7.3 BIOMEDICAL TEXTILES

Medical and biomedical textiles is another extensive research field, with an important market that is not limited to patches, sewing material and bandages. Products range from nonwovens for regenerative medicine such as ear and nose prostheses (Fig.121-123), artificial skin and textile implants including artificial vascular prosthesis and blood vessels to hosiery treated with encapsulated Aloe Vera moisturiser for the wearer's comfort and hygiene. However, there are many more examples of tissue engineering where textile materials are used because of their mechanical and structural properties as well as their high capacity to adapt to biological structures. The term tissue engineering is applicable to all these techniques used to regenerate the tissues or organs of the patient rather than to replace them.[27]

Biodegradable nonwoven scaffolds are used as a three-dimensional cell carrier in regenerative medicine (Fig.119,120). The porosity and degradation profile have to be adjusted according to the tissue being regenerated. Nonwoven prostheses used for the regeneration of the ear or nose made of a biologically absorbable and preformed polymer are in the process of being developed. Living cartilage cells, so called chondrocytes, are seeded into the nonwoven where they form new cartilage tissue. For the time it takes the tissue to grow, the nonwoven is absorbed by the body, leaving the regenerated organ. Nonwoven carriers for the regeneration of defects of cartilage, blood vessels and heart valves, bones, liver and other organs are under development at several research institutions.[28] Among others on the list there are the Institute for Textile Technology and Process Engineering, Denkendorf in Germany and the Massachusetts Institute of Technology in the United States. These developments are highly sophisticated and presumably will take some more years.

Other medical implant types are artificial vascular prosthesis and trachea prosthesis to replace the original vessel if needed. These textile products are made employing more conventional textile technologies such as warp knitting or weaving. When engineering these medical products, essential issues such as biological compatibility and durability have to be particularly considered.





114, 115 The technology for Smart Shirt was originally undertaken for military applications. The fabric includes a complex grid of fiber optic sensors that can be enhanced with further monitoringdevices specific to each application and the information needed.

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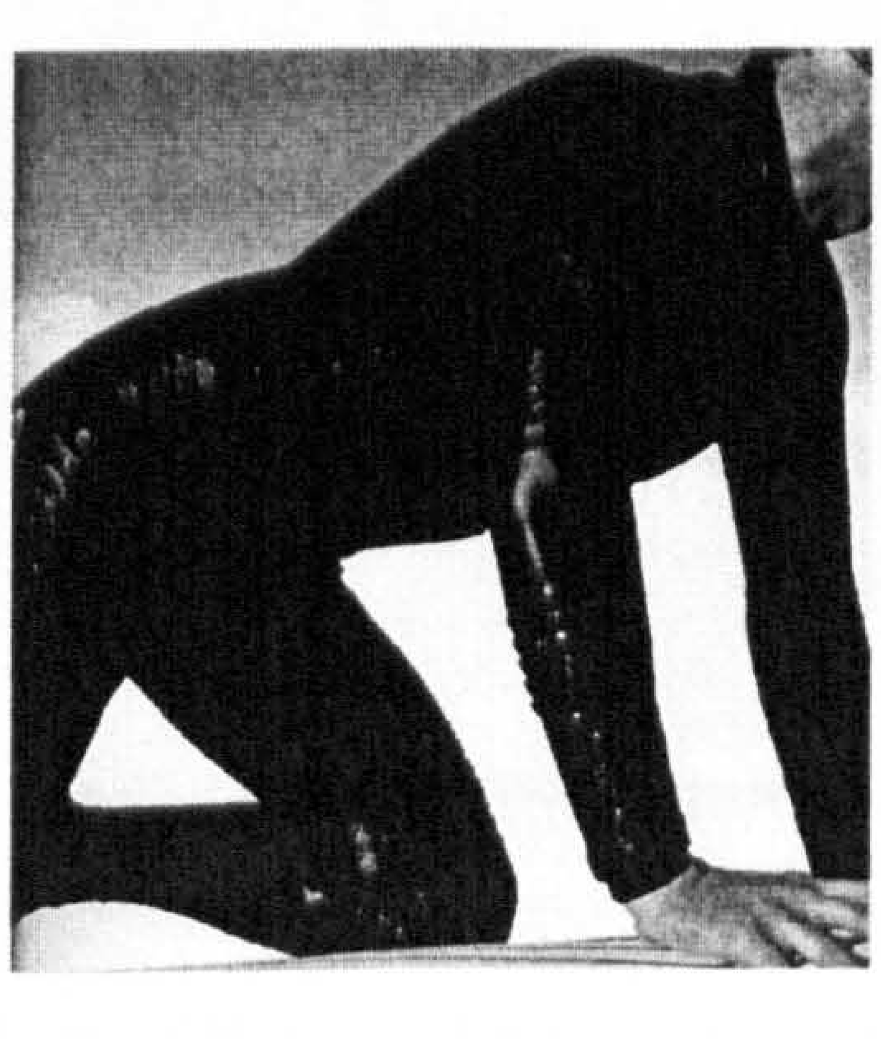
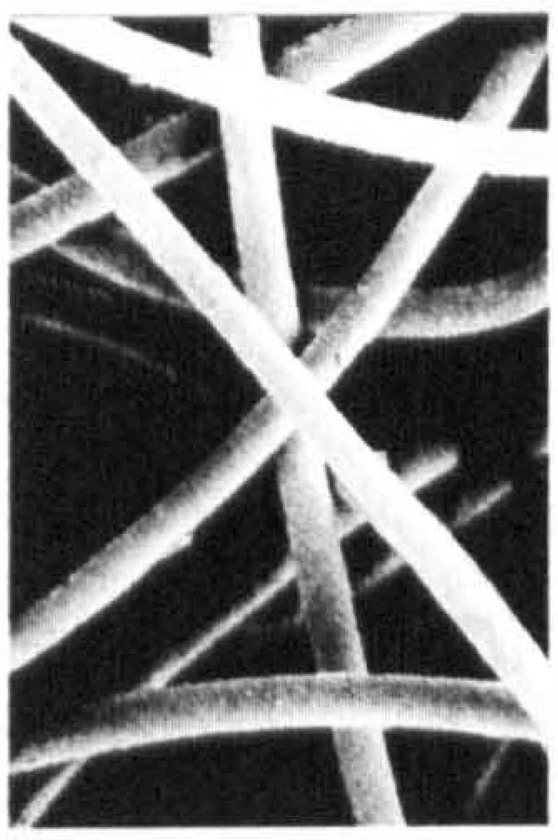
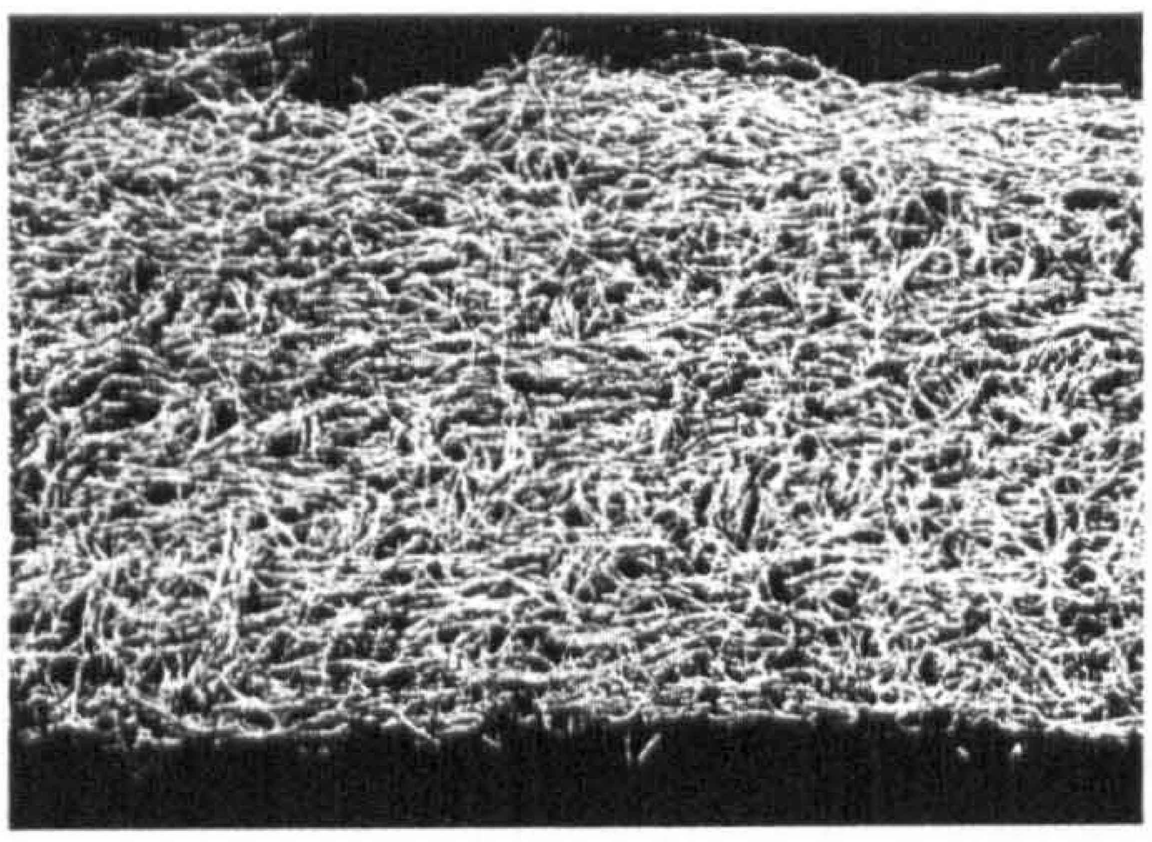


116 Speedo's Fastskin bodysuit is inspired by shark skin.

117 Scales from the skin of a shark. Shark's scales considerably reduce the water resistance around the skin of the shark. Coloured scanning electron micrograph.

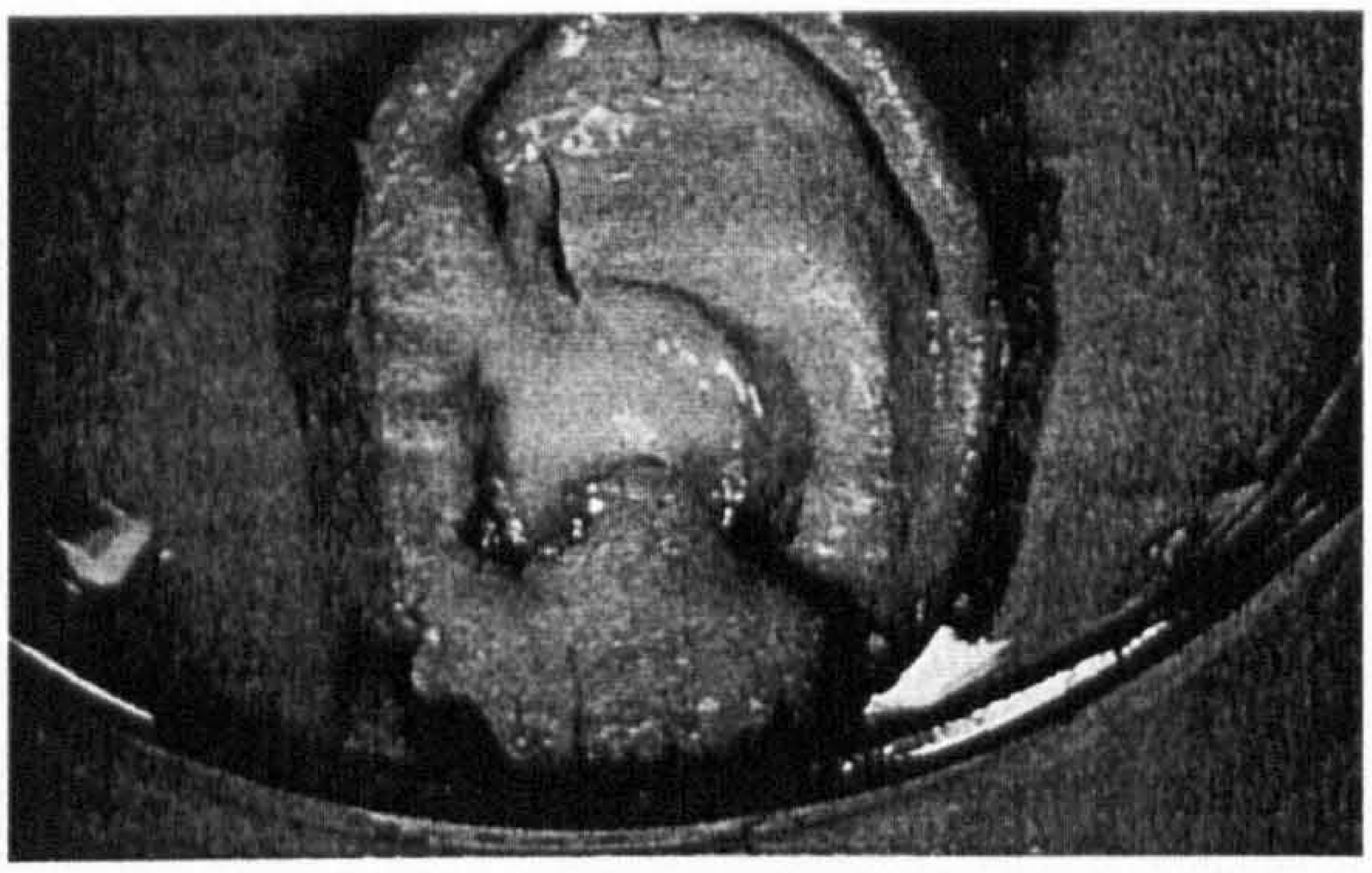
118 O'Neill's Animal wetsuit, which utilises the Expansion System.





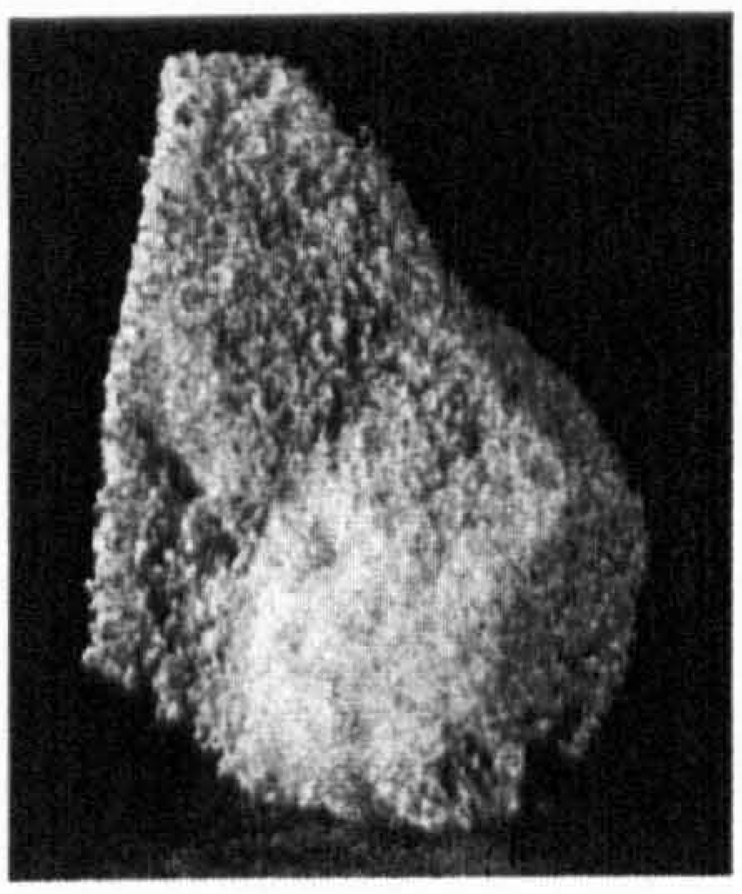
119, 120 Biodegradable nonwoven scaffolds are used as a three-dimensional cell carrier in regenerative medicine. These images are showing the structure of the biologically absorbable polymer nonwovens at two different magnifications.

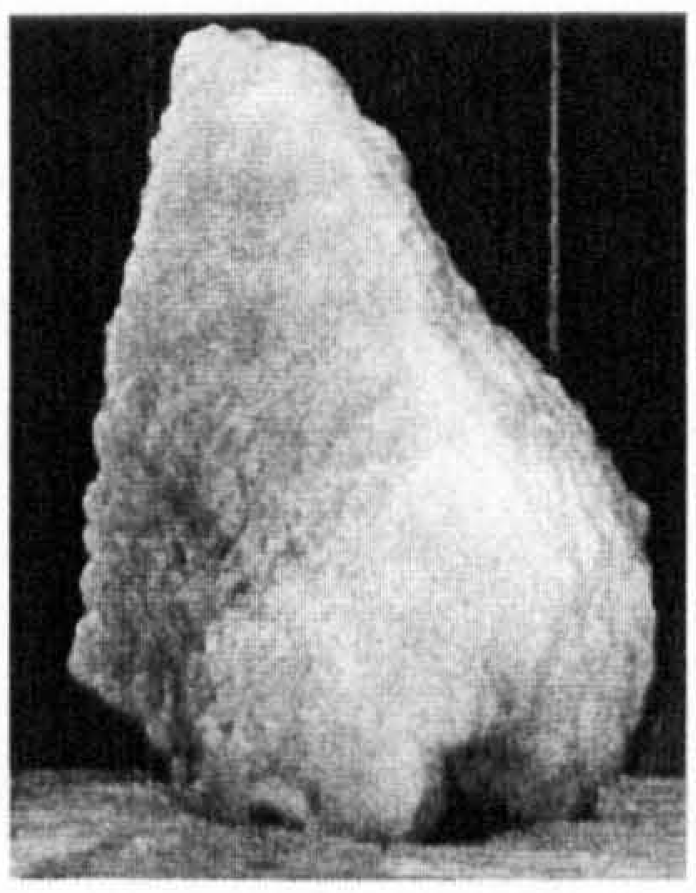
119, 120



121 Cartilage ear.
This ear was made by seeding a synthetic polymer scaffold with cartilage cells, which gradually replaced the polymer with engineered tissue. This transplant can be used in regenerative surgery.

121





122, 123 Cartilage nose.
These images are showing 'before' and 'after' images of the synthetic polymer scaffold (in the shape of a nose) seeded with cartilage cells.

Living cartilage cells, so called chondrocytes, are seeded into the nonwoven where they form new cartilage tissue. For the time it takes the tissue to grow, the nonwoven is absorbed by the body, leaving the regenerated organ. Human cells can be easily obtained by nipping a microscopic sample of the cartilage from the ear and growing cells in a Petri dish.

122, 123

Another important group of bio-functional textiles consists of cosmetic and therapeutic textiles. In the last century standards of life and hygiene were increasingly improving and people nowadays are more aware of issues of cleanliness and hygiene. The textile industry is concentrating research and product development on textiles with anti-bacterial and odour-neutralising properties which have applications not only in the medical sector but also in sports and leisurewear, outdoor textiles, technical textiles and for domestic use.[29] These aspects of biomedical textiles are of a particular interest for my research as I am aiming to develop filtering and curative textile membranes based on analogies of skin functions.

Silver is traditionally well known for its anti-bacterial properties. It effectively kills bacteria and microbes located on the skin. Silver is also a good insulator, protector against electromagnetic waves and has anti-static qualities. Currently on the market there are textile products under different trade names which have utilised the curative properties of silver. Amongst them there is Padycare®, underwear and bed covers with silver coating to help against atopic eczema, acne, fungis and other skin diseases. The producer, German company Tex-A-Med, claims that besides the anti-bacterial and therapeutic benefits, Padycare® textiles can withstand many launderings.[30] X-static® is the tradename of a silver fibre made with a layer of 99.9% pure silver. It is permanently bonded to the surface of a textile fibre assuring good performance for the user. Currently there are socks made of X-static® commercially available, which eliminate odour-causing bacteria.[31]

Adding skin benefits by applying moisturiser, essential oils, vitamins, deodorants and even insect repellent to a textile substrate is possible using microencapsulation technology. The use of encapsulated cosmetic oils in hosiery, nightwear and sportswear is particularly recommended. 30% of women are unable to wear hosiery due to the nature of the garment, which dries out natural moisture from the skin. Celessence International LTD claims that as a result of their research and technology of applying microencapsulated Aloe Vera during the wet processing of hosiery manufacture, the problem is overcome. This opens up a potential new market.[32]

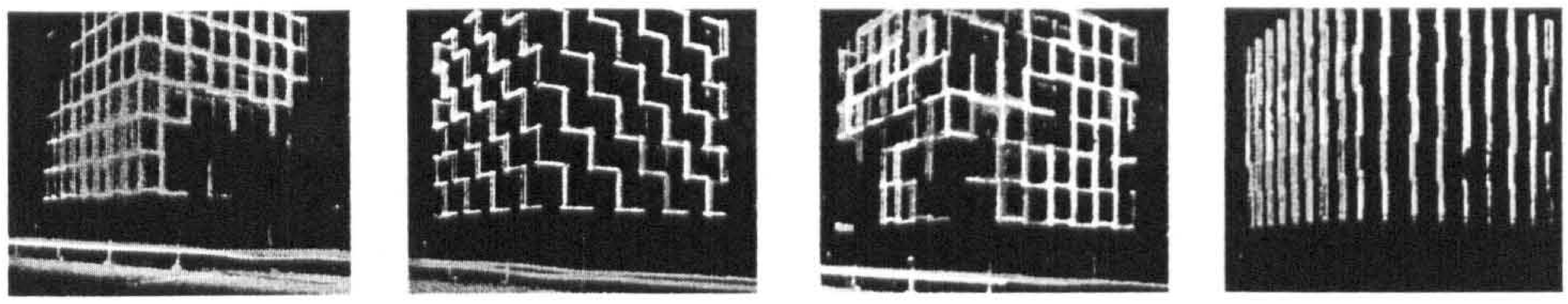
7.4 SKINS OR MEMBRANES IN ARCHITECTURE

Today, architects too are talking about the 'skins' of their buildings, tensile architectural membranes and responsive systems. They 'are confronting the focus on surface and skin in today's culture and technology.'[33] New, innovative and multifunctional materials with optimised properties are therefore welcome in this new reality. Dutch architect Denk Döll from Mecanoo Architects agrees: 'It is not only the technical performance, the structural possibilities or the physical properties that interest us, we are above all concerned with the visual and architectural impact of the material, its contribution to the image of a building.'[34]

Eberswalde Technical School in Germany designed by architects Jacques Herzog and Pierre de Meuron is one of the buildings where they 'focus on conditions of skins, layers and shells. [...] They compress allusions to the depth of the interior into the surface of the building'[35] by creating multi-layered exteriors and applying figurative imagery to them (Fig.128). Resembling tattooed skin, images are engraved onto the building's concrete surface while using a more specialized process to transfer photographs and silkscreen printing onto the glass windows. This repetitive pattern of continuous imagery, as if a cloth were printed, on both the glass and the concrete, camouflages the constituent nature of each material. 'The glass becomes semi-opaque while the concrete attains a shimmering lightness.'[36]

NL Architects are the authors of the sculptural work WOS 8, which is an electrical cooling station, commissioned by the power generating company NUON (Fig.126). The entire surface of the WOS 8 building is coated with seamless polyurethane skin, creating a protective enclosure for an internal mechanism helping to reduce heat and noise emissions. 'Developed for rooftop car parks, the polyurethane skin is attractive, incredibly strong, durable and chemically inert.'[37] WOS 8 facades are designed for various functions embodying the concept of 'a public square wrapped around a machine.'[38] There is a basketball wall (with the building's only window for throwing balls at), a climbing wall (with a pattern of subcutaneous climbing grips) and a bird wall (the building's skin incorporates nesting boxes). Its vulcanised landscape roof serves as a rainwater collector and the toilets flush with the water collected in a pool.

The underlying idea of the Expomedia Light-Cube in Saarbrücken, Germany by architects Kramm & Strigl is to signalise new developments in the town which recently started its process of transformation (Fig.124,125). Architects designed the office building clad in a translucent garment of woven stainless steel net which encases the entire surface as a second skin. The membrane is fixed approximately a metre away from the interior body, creating a gap between inside and outside. Additionally, behind its mesh-like surface structure, another layer of a more robust metal grid is set. On this level, a modular system of LED tubing is integrated. LED's create coloured light patterns at night, going through the RGB colour spectrum by changing colour in a preprogrammed way.[39]



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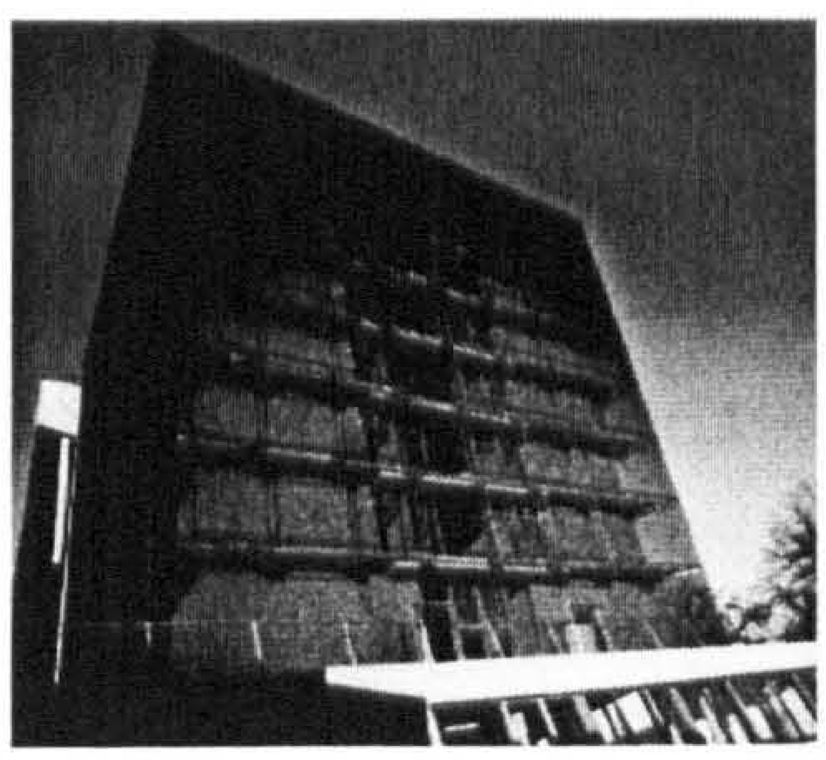

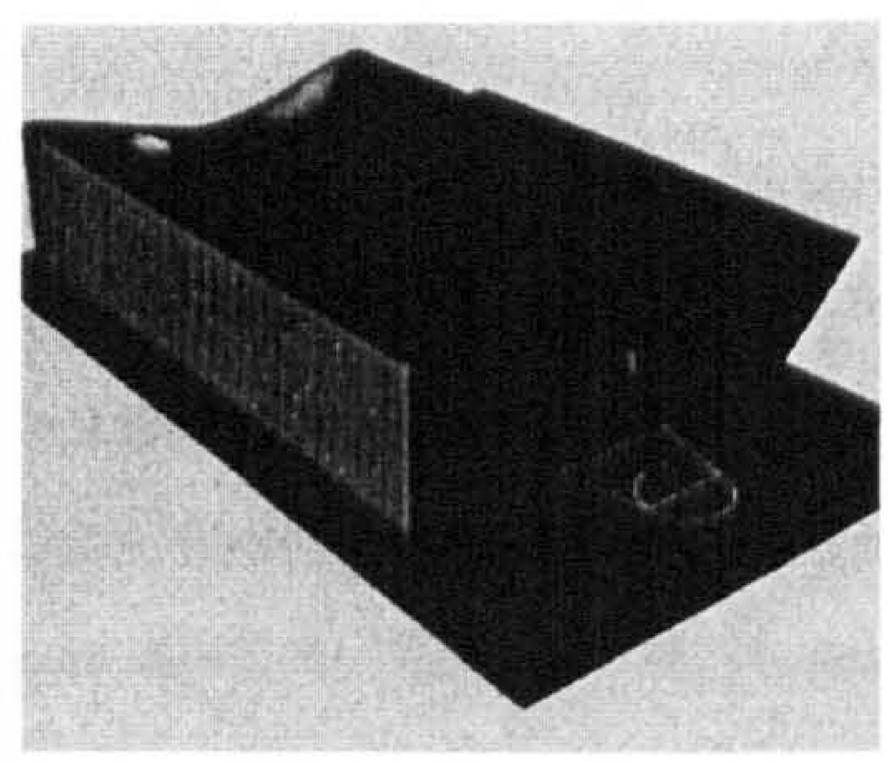

124, 125 The Expomedia Light-Cube in Saarbrücken, Germany by architects Kramm & Strigl. LED's create coloured light patterns at night, going through the RGB colour spectrum by changing colour in a pre-programmed way.

126 WOS 8 coated with seamless polyurethane skin by NL Architects.

127 Eberswalde Technical School in Germany designed by architects Jacques Herzog and Pierre de Meuron.

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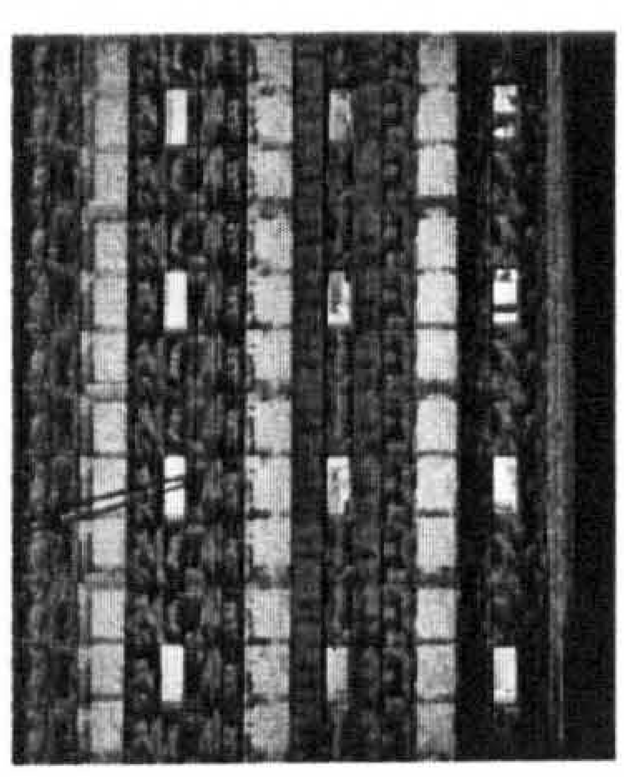

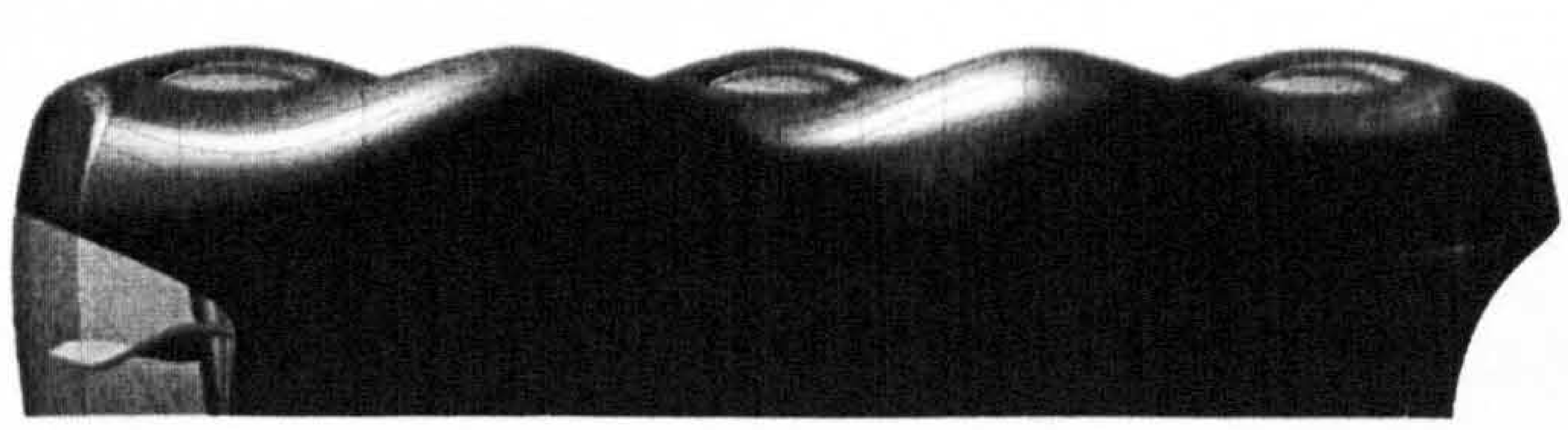

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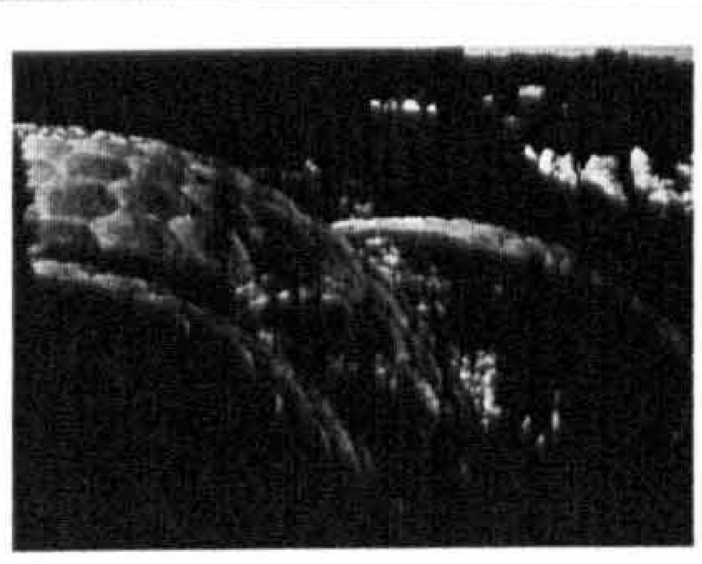

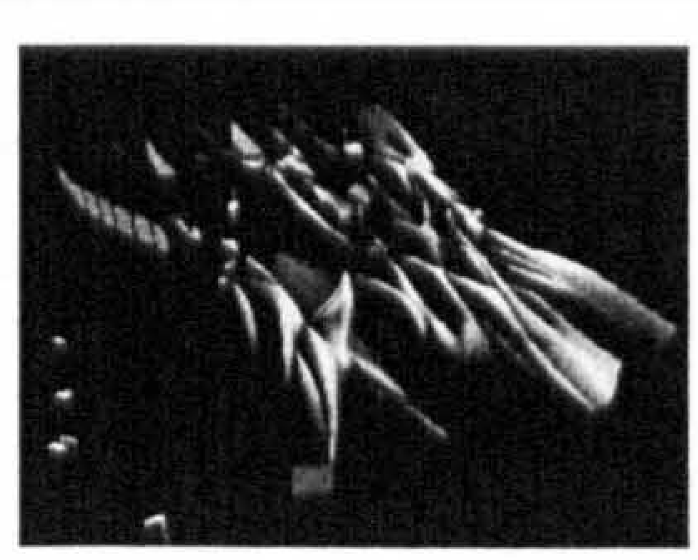

128 Mercedes-Benz Museum of the Automobile by Asymptote architects has an organic appearance. Exhibition space is wrapped in a smooth overall envelope. Stuttgart, Germany, 2001 (competition scheme).

129 Eden Project designed by Nicholas Grimshaw & Partners. Cornwall, UK, 2001

130 Soft Office by NOX, England, 2000-2005. The exterior of the Soft Office is covered with a skin-like membrane that emphasises the organic structure of its interiors, modelled using a natural precedent in the tissue of porous bone.

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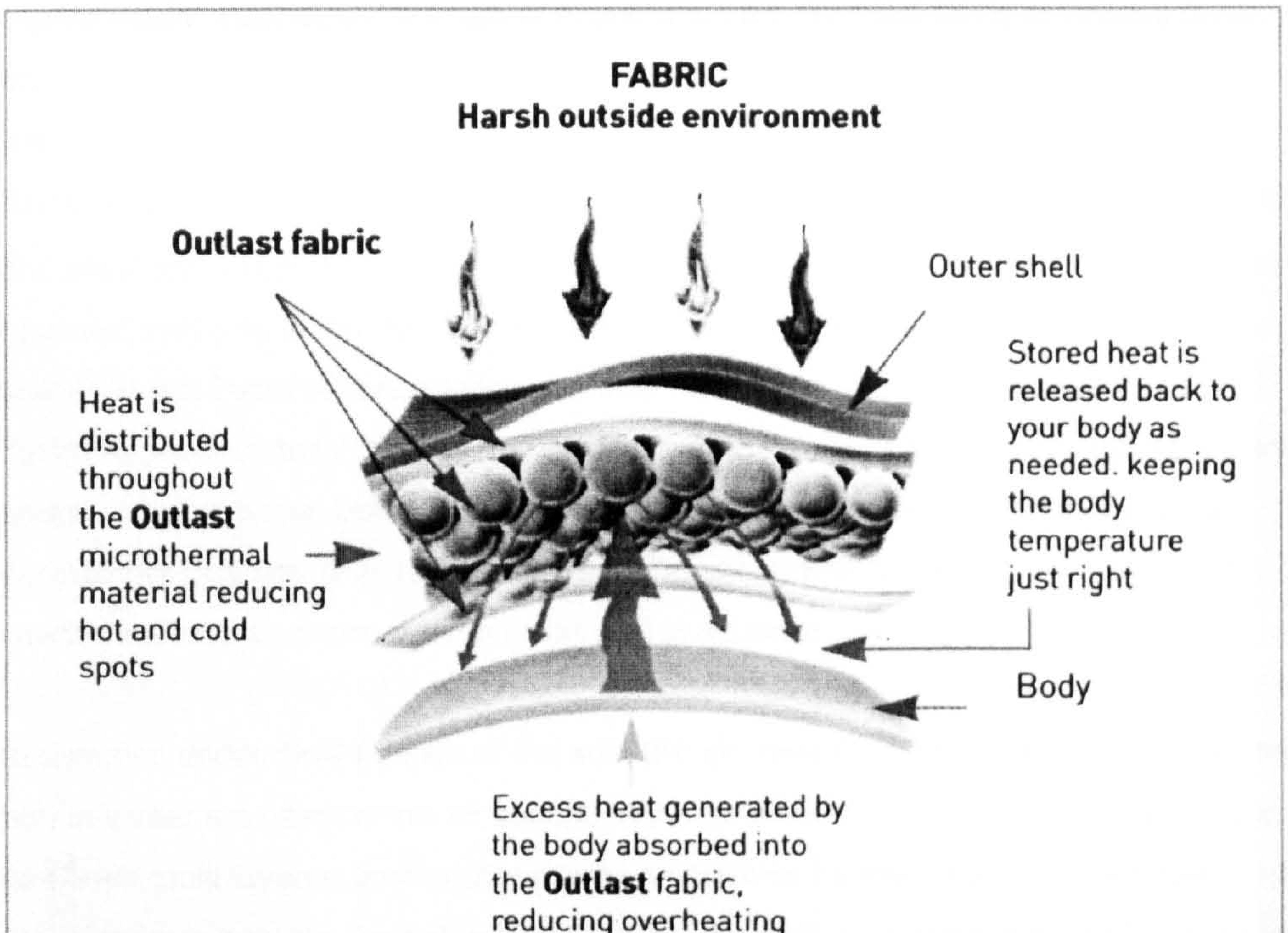


131 Outlast Technologies, Inc, uses phase-change technology for a microthermal material that absorbs excess heat, evenly distributes it over its surface and stores it in order to release it gradually as the body cools after activity. Both companies Outlast Technologies, Inc and Schoeller are researching the possibilities of integrating the PCMs in architectural materials.

Another specific interest for architects is the use of membrane structures for roof constructions. Tensile systems are increasing in the building sector, especially to cover sport stadiums or as a huge sun protector (Moshe in Mecca). Membrane structures are in demand for permanent tensile systems as well as for temporary projects which can be easily erected, still remaining strong and firm. By 1980 fabric structures based on glass fibres or polyesters were being increasingly used.[40] The material technology and design know-how is already available to offer highly sophisticated solutions. Textile materials possess significant mechanical advantages: minimum weight, flexibility and elasticity. A serious disadvantage is their lack of sufficient heat and cold insulation, however, and only when this problem is solved can the incorporation of textile membranes in architectural constructions be truly successful. American company Outlast Technologies Inc. and American-Swiss company Schoeller Frisby Technologies AG are addressing this issue. Both have developed patented Phase Change fabrics named accordingly Outlast® (Fig.131) and ComforTemp® mainly for sports clothing sector, which can 'keep us warm in winter and cool in summer'.

In summer, under the influence of the sun, the air beneath the membrane becomes too hot. In winter too much warm air escapes into the environment. Until now, the solution has been multi-layered constructions, with air pockets for insulation between these layers in order to balance the entire construction. Recently new solutions such as coating or bonding the Phase Change Materials (PCM) on the textile materials have been considered to improve the architectural membranes. These solutions are site specific. For instance, in Germany typical temperature ranges between –25°C and +35°C should be considered. The most appropriate PCM for textile applications is a mix of different types of paraffin taking into consideration their thermo-physical characteristics.[41]

PART II

(RE)MAKING THE SKIN THROUGH THE MEDIUM OF TEXTILES

SKIN STORIES :: INTERACTIVE TEXTILES FOR A CONCEPT OF 2ND AND 3RD SKIN

CHAPTER 08 ::

PRACTICE STEP I
CHARTING AND MAPPING THE SKIN

08 PRACTICE STEP I - CHARTING AND MAPPING THE SKIN

'[...] medical technologies of genetics and of body imaging have opened the way to new artistic visions of the body and have brought a growing convergence between science and art.'[1] ***Andrews & Nelkin***

Our skin is a naturally beautiful surface. It also can be viewed, investigated and represented at various levels using the aid of a microscope. According to the set methodology, during the first stage of the practice led research, anatomical structures and textures of human skin tissue were examined using scientific microscopic imaging technologies. This work was conducted at the Institute for Biology and Zoology, Freie Universität Berlin, Germany, where regular access to bio-medical facilities and laboratories for micrography imaging was arranged, under the supervision of Prof. Dr. Klaus Hausmann.

Astonishing magnified skin landscapes were recorded whilst tracing the surface and cross-sections of skin under the microscope, in the form of photomicrographs, slides and videos. These visuals were then transferred into digital data and selected images were manipulated according to personal aesthetic and design considerations and transformed into patterns for screen printing using 'skeletonisation' or 'thresholding' methods (08.3). Another investigative method for the three-dimensional analysis of skin relief called the 'shadowing principle' (08.4) used in dermatology was applied for the creation of dimensional textile designs and sculptural objects. The data resulting from these scientific experiments form the basis and reference for further design work by helping to develop an aesthetic language for the project, and thereby enabling the complex nature of the skin to be studied.

A light microscope (08.1) and a scanning electron microscope (08.2) were used in order to identify the essential aspects of skin physicality, namely its surface patterns that are related to the 'topography' of skin, as well as its structure and three-dimensionality related to the 'architecture' of skin. These, together with theoretical information on skin biology and its functions, form a picture of the skin as a 'technology' and informed my practice.

08.1 LIGHT MICROSCOPY

A light microscope was used to study anatomical skin structures and textures. It employs optical lenses capable of magnifications up to 1000x and provides flat representations of the structures investigated.

Tiny objects, such as bacteria or single cell organisms, can be viewed in whole under the light microscope. Larger tissues must first be carefully prepared. They are chemically preserved, embedded in a supporting material such as wax or similar, and sliced very thinly in order to be mounted on special glass slides. Such specimens are often coloured with specific dyes before viewing to pick out particular components of the tissue.[2] Other types of biological specimens called negative replicas or casts for the analysis of microreliefs of organisms also have to be produced prior to investigation. However, this is a non-invasive method and therefore relatively fast. In dermatology nearly all image analysis of skin microrelief are based on replicas, which are prepared using various base materials such as dental resins, transparent nail polish or others (Fig. 135).

A variation of light microscopy, also employed in this research, uses differential interference contrast optics. This technique depends on polarized light being slightly bent as it passes through tissues. The differences in the composition of different cells within the specimen cause slight changes in the bending of the light. After the light has passed through the tissue it passes through another polarizer. Tissues that have bent the light to various degrees appear darker or lighter, thus enhancing contrast and giving a brilliantly coloured, almost three-dimensional appearance (Fig. 138, 139).

08.2 SCANNING ELECTRON MICROSCOPY

Additional scientific imaging technology included scanning electron microscopy (SEM), which uses an electron microscope to visualise surface characteristics of an object from low to very high magnifications, allowing views 10,000 times smaller than the human eye can see. SEM is used to study the three-dimensional aspects of a specimen and employs electric or magnetic lenses rather than the optical lenses of a light microscope.[3]

Prior to SEM investigations biological specimens must be chemically preserved and impregnated with a chemical called osmium, then dehydrated with increasing concentrations of alcohol. They are then dried, mounted on an aluminium stud, sprayed with a very thin layer of gold and viewed under the electron microscope. The electron beam causes electrons to be emitted from the surface of the specimen and gives rise to varying voltage signals that form the image on a high-resolution television screen. The image, which is always black and white, is recorded by a conventional photographic camera on film or processed by a computer to generate a digital image. Biological specimens are sprayed with a layer of gold to improve the emission of electrons from the surface.[4]

08.3 SKIN TOPOGRAPHY

In order to analyse the surface patterns or 'topography' of the skin using a light microscope, biological skin specimens had to be prepared, employing the non-invasive method of taking skin impressions or negative replicas of the skin surface, from voluntary donors.

The method of obtaining skin microrelief casts from donors used in this investigation is harmless, quick and simple: some transparent nail polish is applied thinly on the selected area of the skin, typically on an arm and a forehead. After a few minutes the dried nail polish film embedding the original negative skin cast is removed, with the help of adhesive tape, and mounted on a glass slide. These skin replicas are then ready for investigations using the light microscope (Fig. 134).

The use of this method allows one to study and compare different surface patterns of skin from people of different race, age and gender. For reference a Polaroid photo was taken of each of the six volunteer donors who were aged from 25 to 59 years old, three women and three men. Of these, two were Latvians, one German, one Japanese, one Italian and one Guanine (Fig. 145, 146).

Selected photomicrographs obtained from the negative replicas of the skin surfaces were digitally manipulated in order to develop designs for screen printing. Digital segmentation or filtering of the skin patterns used in creative work relates to the method of the so called 'skeletisation' or 'thresholding' of the initial image of skin replica used in dermatology, a method adopted by scientists in order to detect the development of furrows.[5] The negative skin surface image is typically filtrated, reinforced and thresholded using special computer software, transforming the initially smooth image into a two-level image representing the lines and the background as seen in
Figures 142 – 144.

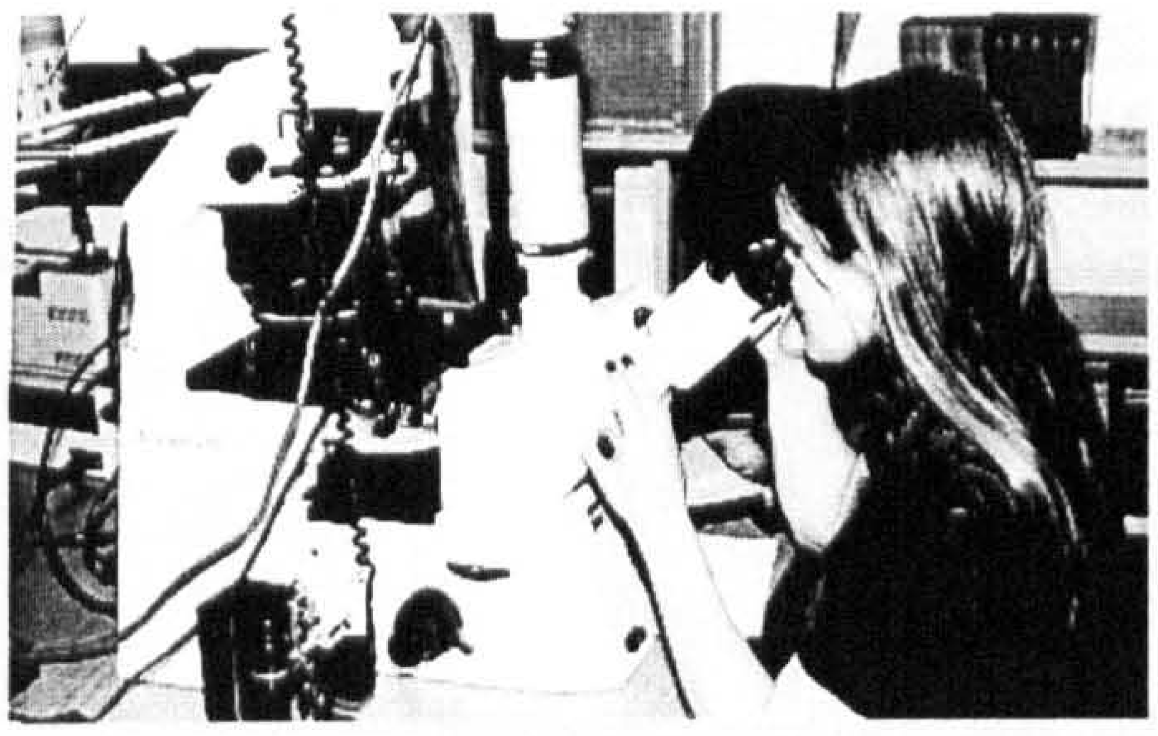
08.4 SKIN ARCHITECTURE

In order to investigate the structure or 'architecture' of the skin, prepared skin samples (see 08.1) using light microscope were studied (Fig. 133). These biological slides typically feature cross-sections, parallel sections and vertical sections of the human skin tissue from the scalp, arm pit, plantar, lip and other non-specified areas, enabling an inside view of the construction and organization of the skin layers and its components as seen in Figure 147.

The readings obtained by the light microscope are typically flat. To inform formation of the creative textiles practice on the three-dimensional aspects of the skin, a scanning electron microscope was used to render 3D readings. The skin biopsy specimens were investigated and the results recorded in the form of black and white photographs (Fig. 140, 141, 148, 149).

Using this method the tiniest structures of skin tissue can be studied and a new perspective on the surface of the skin was obtained. This was very different from the one offered by the light microscope. Personally I was very impressed by the patterns and shapes of dead cells in the outer layer of our epidermis and this served as an analogy for several three-dimensional textile pieces (described in Section 12.1 – *Membranes*).

Another method for obtaining three-dimensional readings of skin relief involved the so called 'shadowing principle' (Fig. 150), originally developed by NASA to study lunar topography.[6] When this method is applied to the topography of negative skin imprints, it gives a three-dimensional analysis of the microrelief. Under oblique lightning, the shadows created behind the negative furrows called crests can be selected and measured, using a mathematical model, that allows us to calculate the total skin area within 1 cm^2 of the projected surface.[7] When applying this method to my creative work I was not so much interested in the dermatological aspects as in the 'shadowing' principle itself. It allows to simplify the visual form by extracting the most basic information, such as depth and orientation, from the skin's furrows. For the development of the base structures of sculptural textile design objects, a reference to this principle was used.

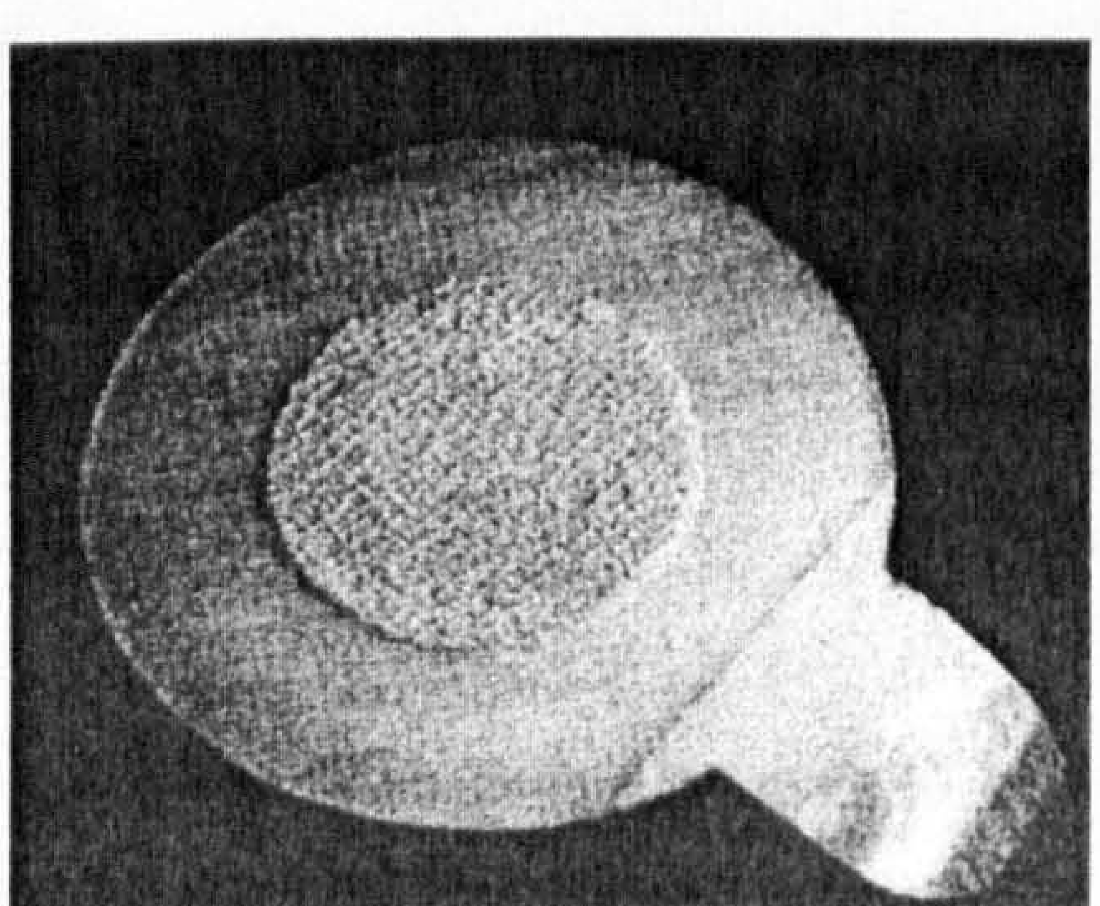


132 The early stages of my research were spent in a bio-medical laboratory environment.

This image features work with the light microscope at the Free University Berlin, Institute for Zoology and Biology.

132

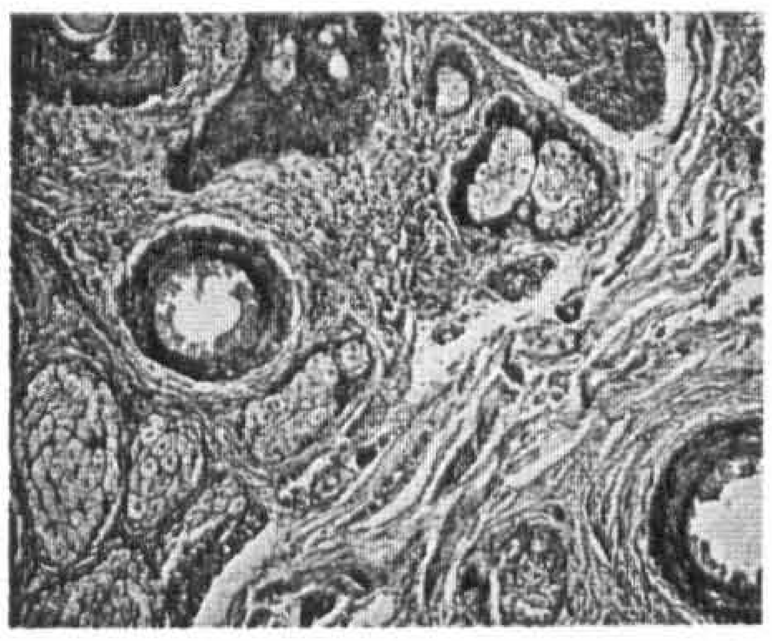
133,134,135↓

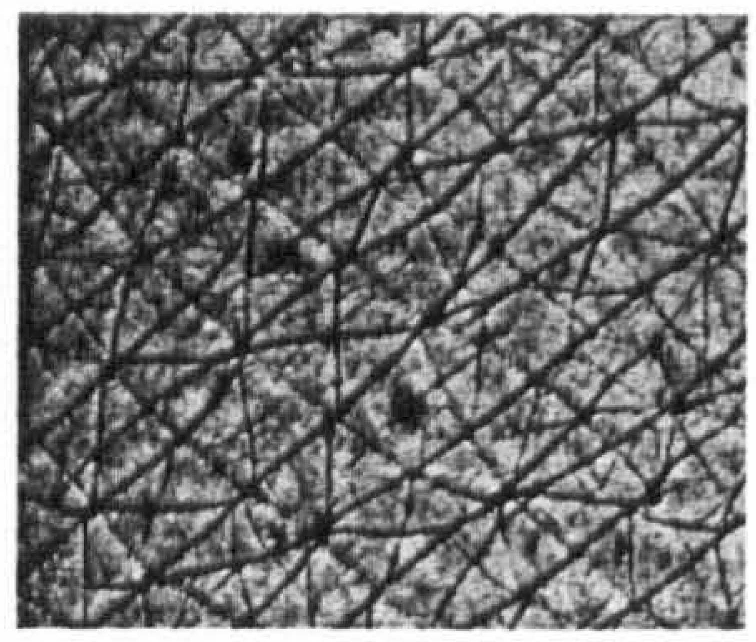


133 Biological skin tissue (chemically preserved). These specimens are prepared for investigation using a light microscope. Skin specimen slides were borrowed from the Beauty Science Department at the London College of Fashion and The Institute for Zoology and Biology, Free University, Berlin.

134 Negative replicas or casts of the skin surface for the analysis of microreliefs of different epidermal surfaces using a light microscope. These biological specimens were obtained using a non-invasive method from volunteer donors.

135 In dermatology nearly all image analysis of skin microrelief are based on replicas, which are prepared using various base materials such as dental resins, transparent nail polish or others. This image features a negative Silflo replica of the surface of the forearm inserted in an adhesive paper ring.



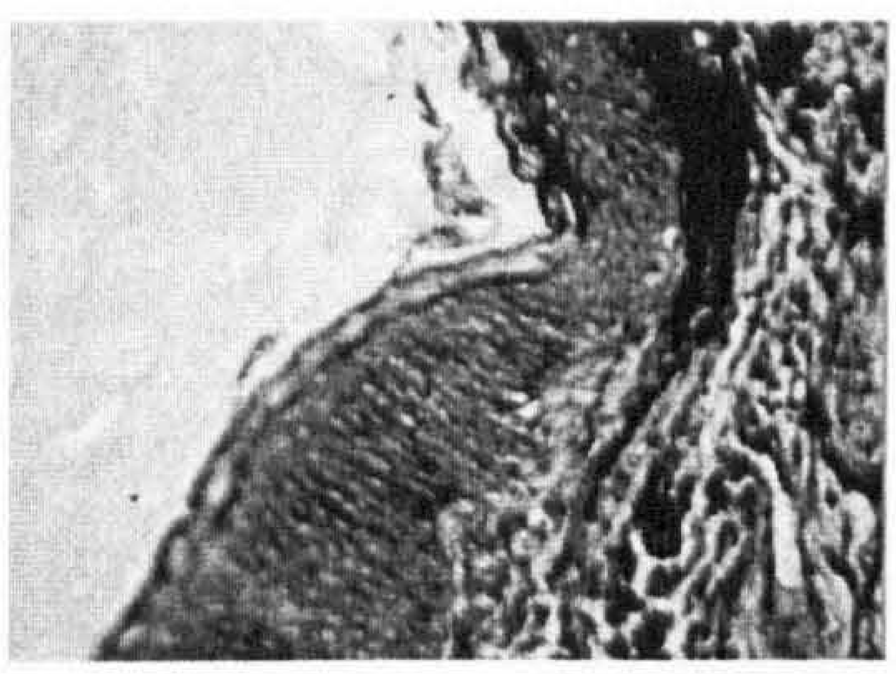


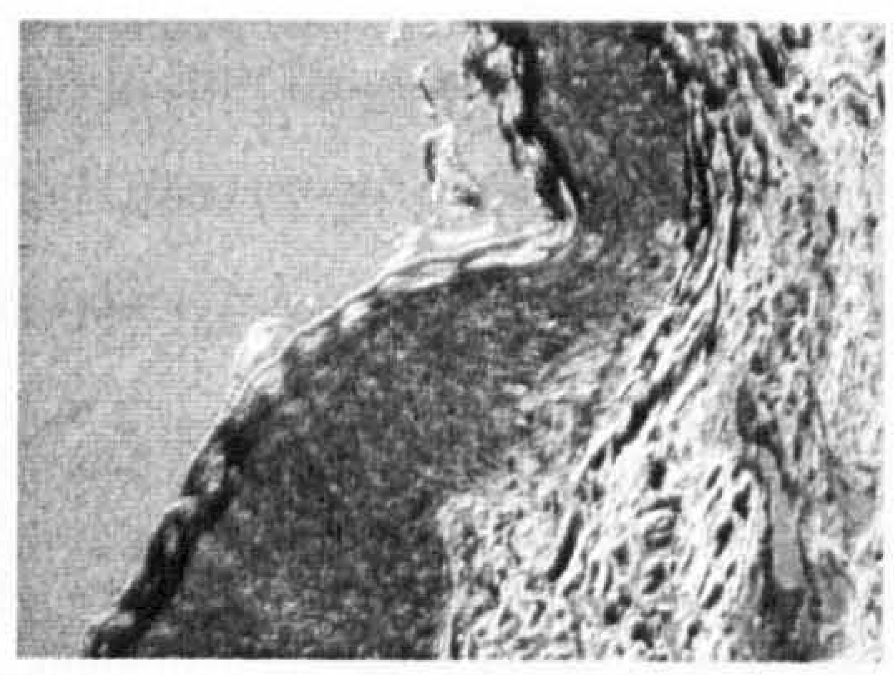
Typical light micrographs:

136 This micrograph is taken using chemically preserved skin tissue from a human scalp and shows the 'architecture' of skin.

137 The micrograph is obtained using a negative skin replica of the surface of the forearm.

136, 137





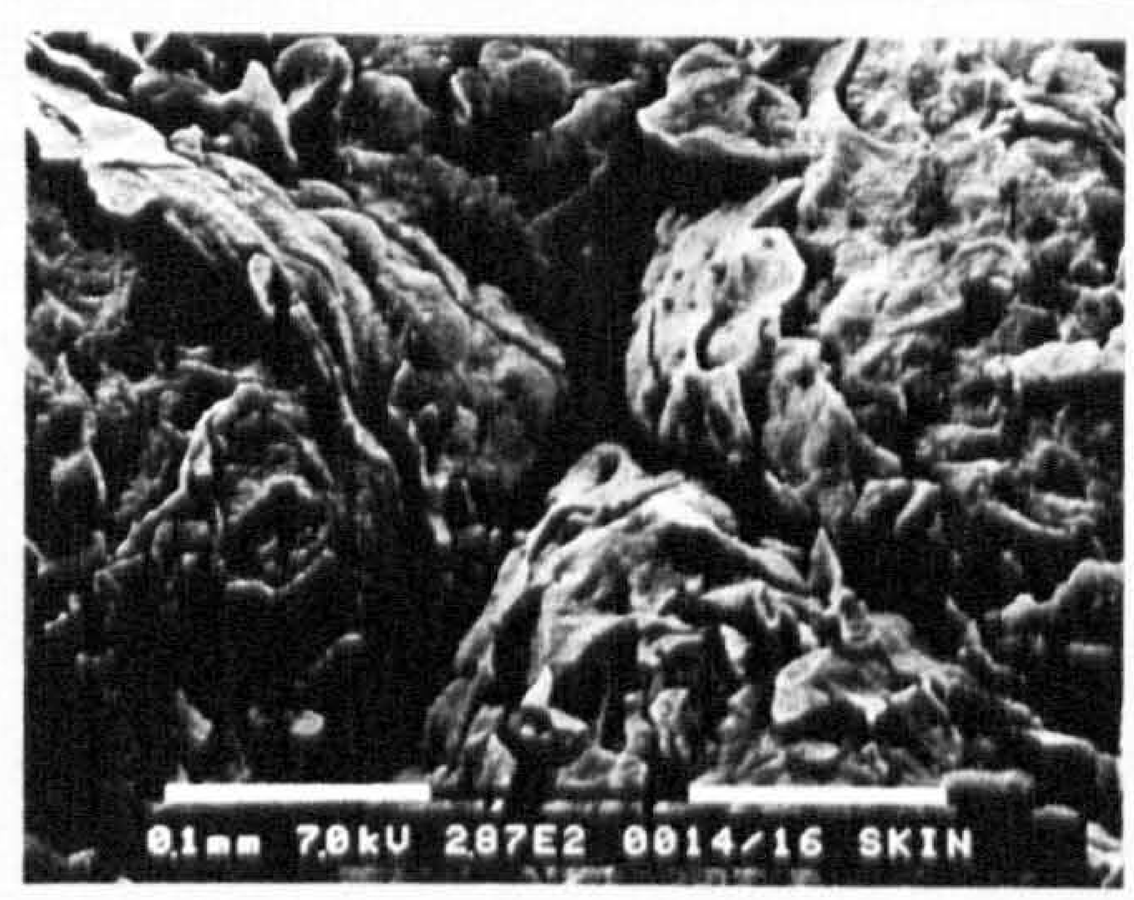
138 Human scalp, vertical section. Light micrograph, low magnification.

139 Human scalp, vertical section. The same area as in Figure 138 - an example of polarized light micrograph. Light micrograph, low magnification.

138, 139

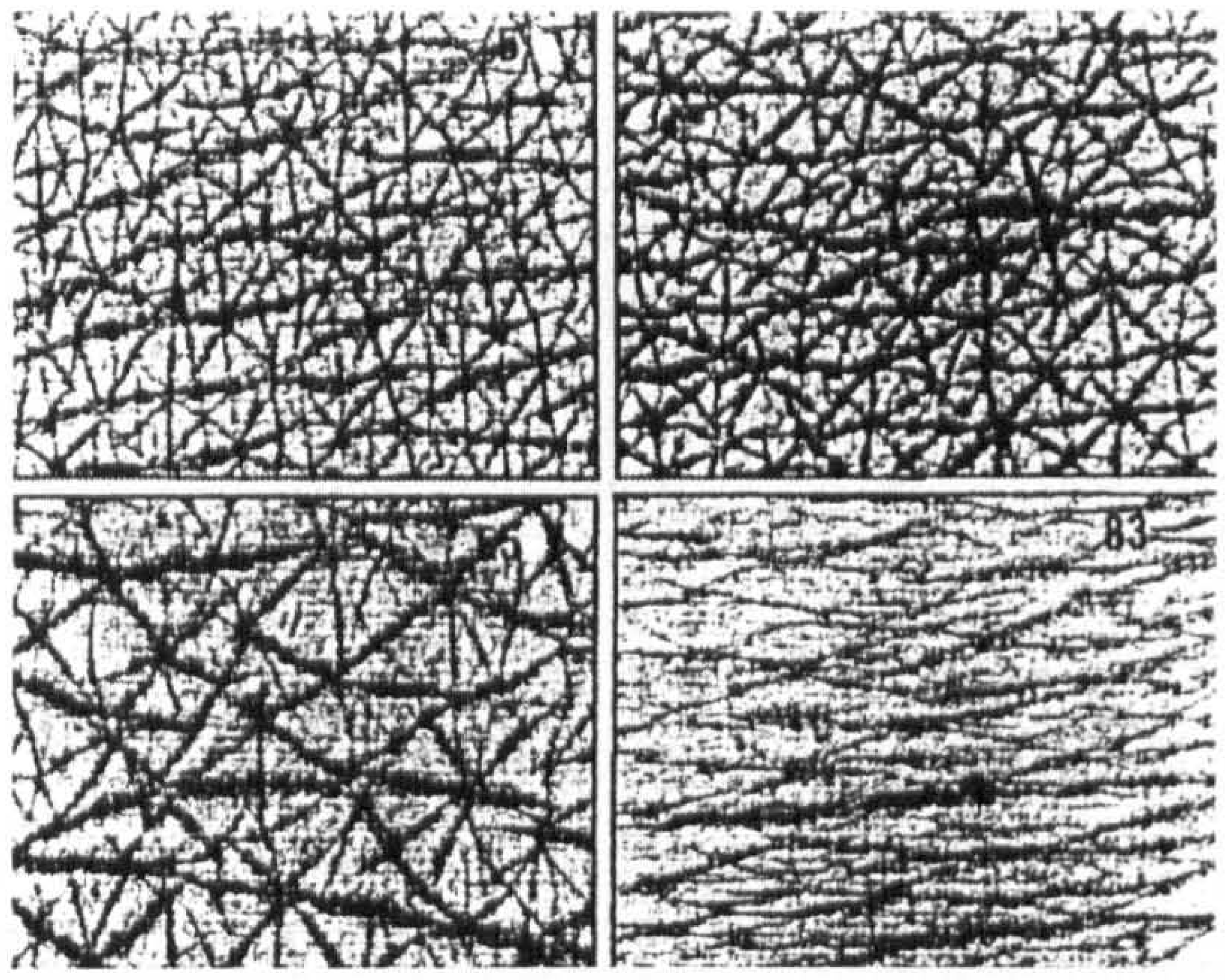
140 Biological skin specimens prepared for a scanning electron microscope.

141 3D skin image taken using a scanning electron microscope shows the skin cells of the epidermis. High magnification.



140

141



Skeletonization of initial image of skin replica used in dermatology:

142 Initial skin surfaces: male subjects 5, 25, 55 and 83 years old.

143 Skeletonization of furrows (same areas as in Figure 142).

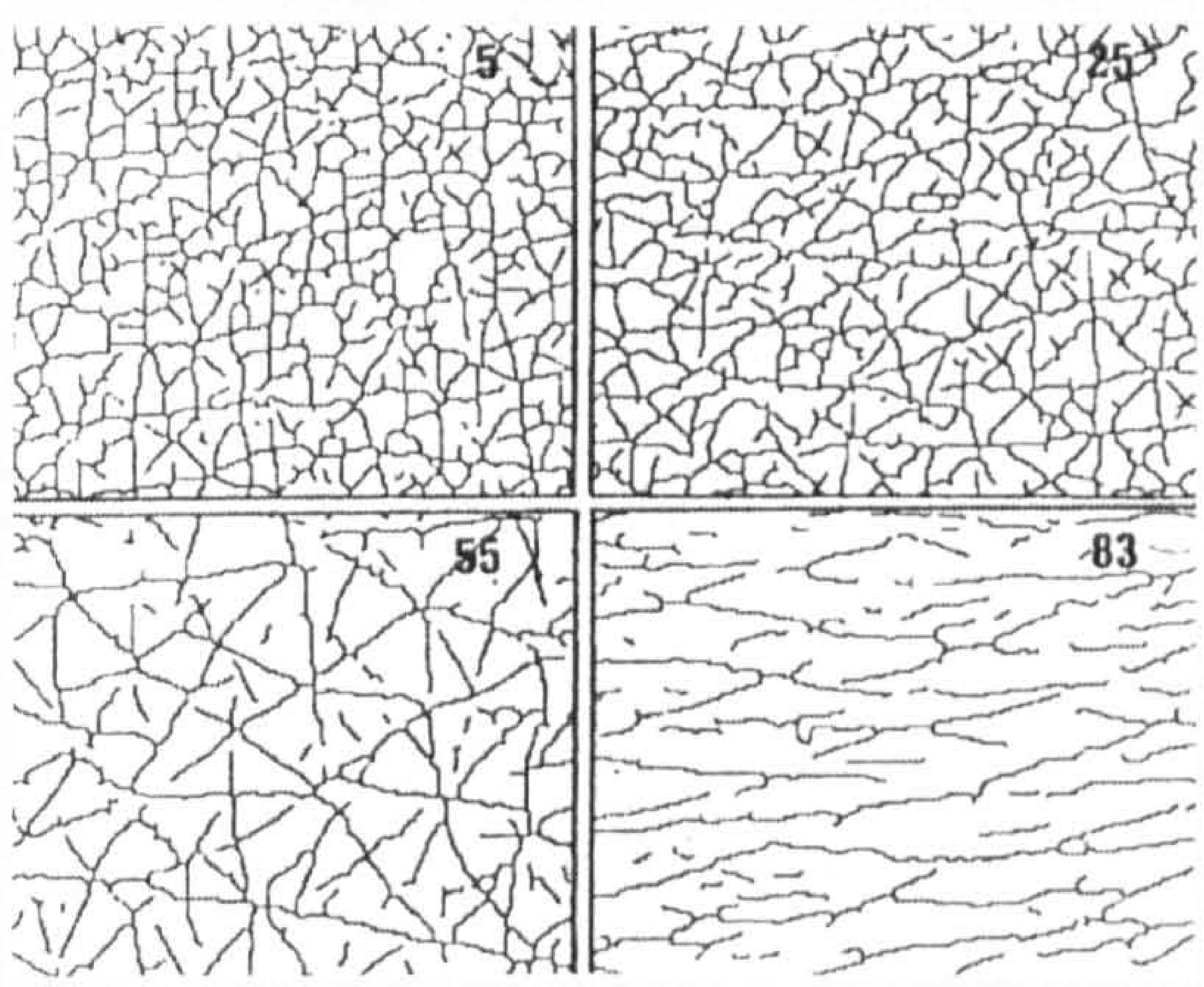
144 Detection of furrows using the method of image thresholding or filtering:

A = Initial skin surface

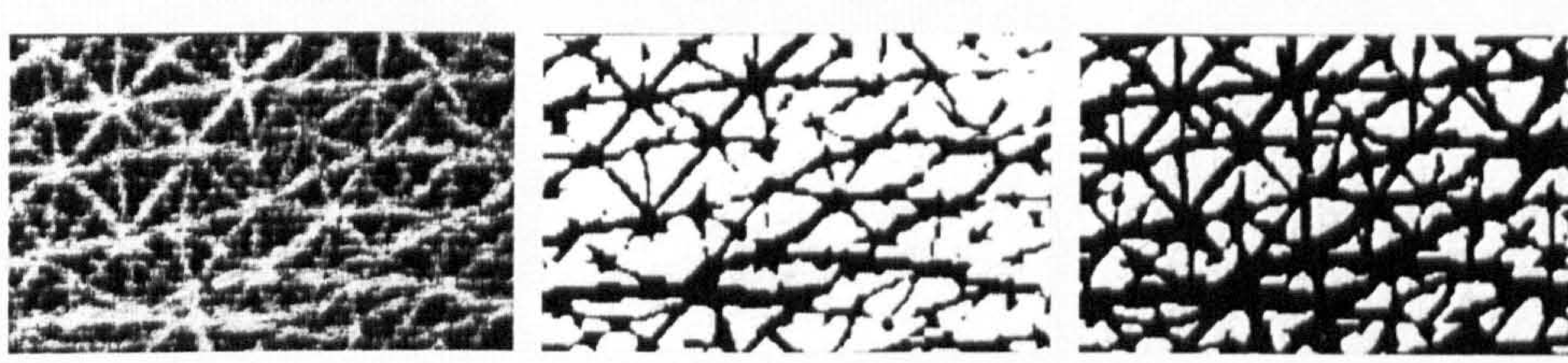
B = Thresholding the image: level = 20

C = Thresholding the image: level = 30

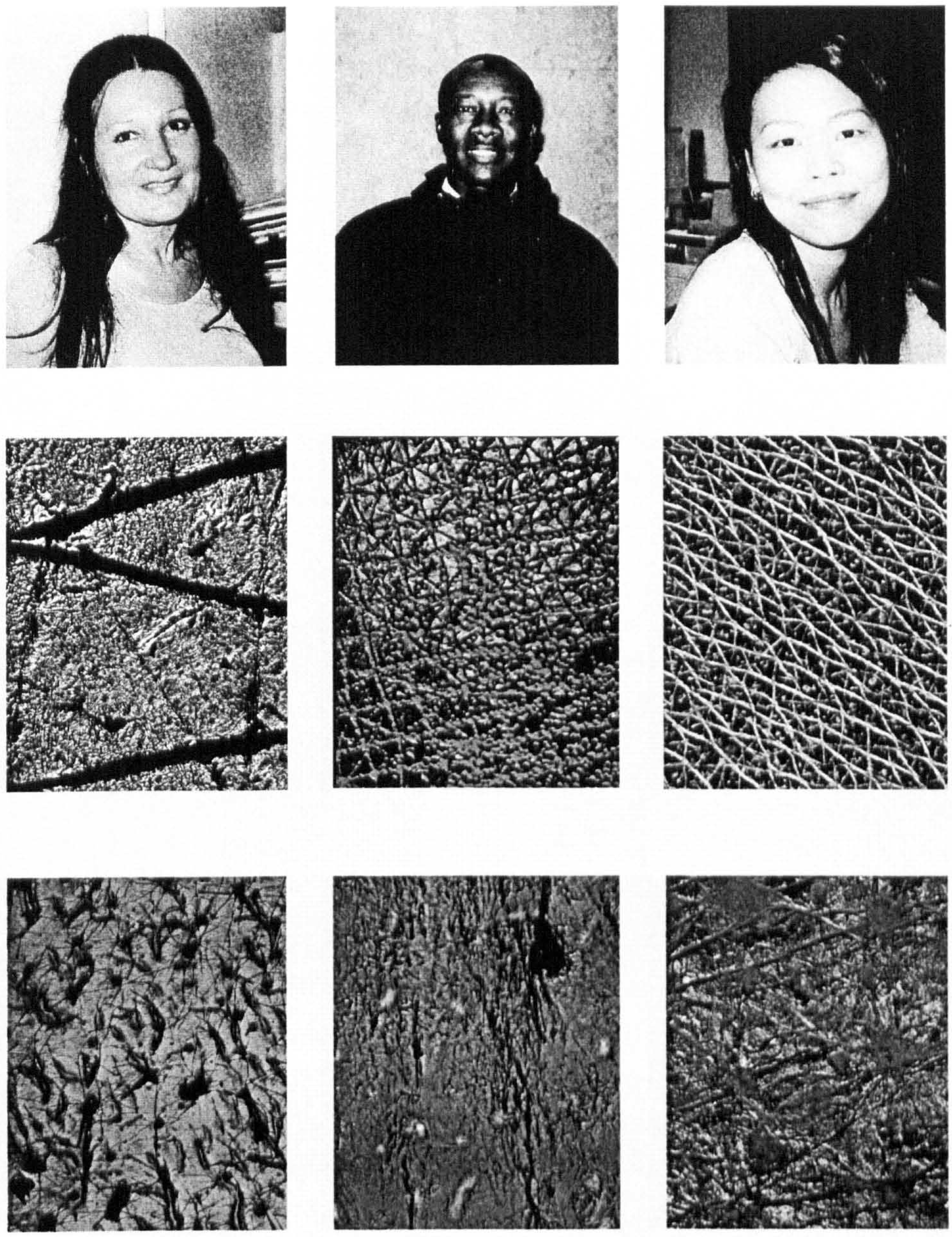
142



143



144 (A, B, C)



Donor: ASTRIDA
Female, 55 years, Latvian.
Polaroid photo.

#S69 Forearm
High magnification.

#S13 Forehead
Low magnification.

Donor: PRINCE
Male, 30 years, Guanine.
Polaroid photo.

#S39 Forearm
Low magnification.

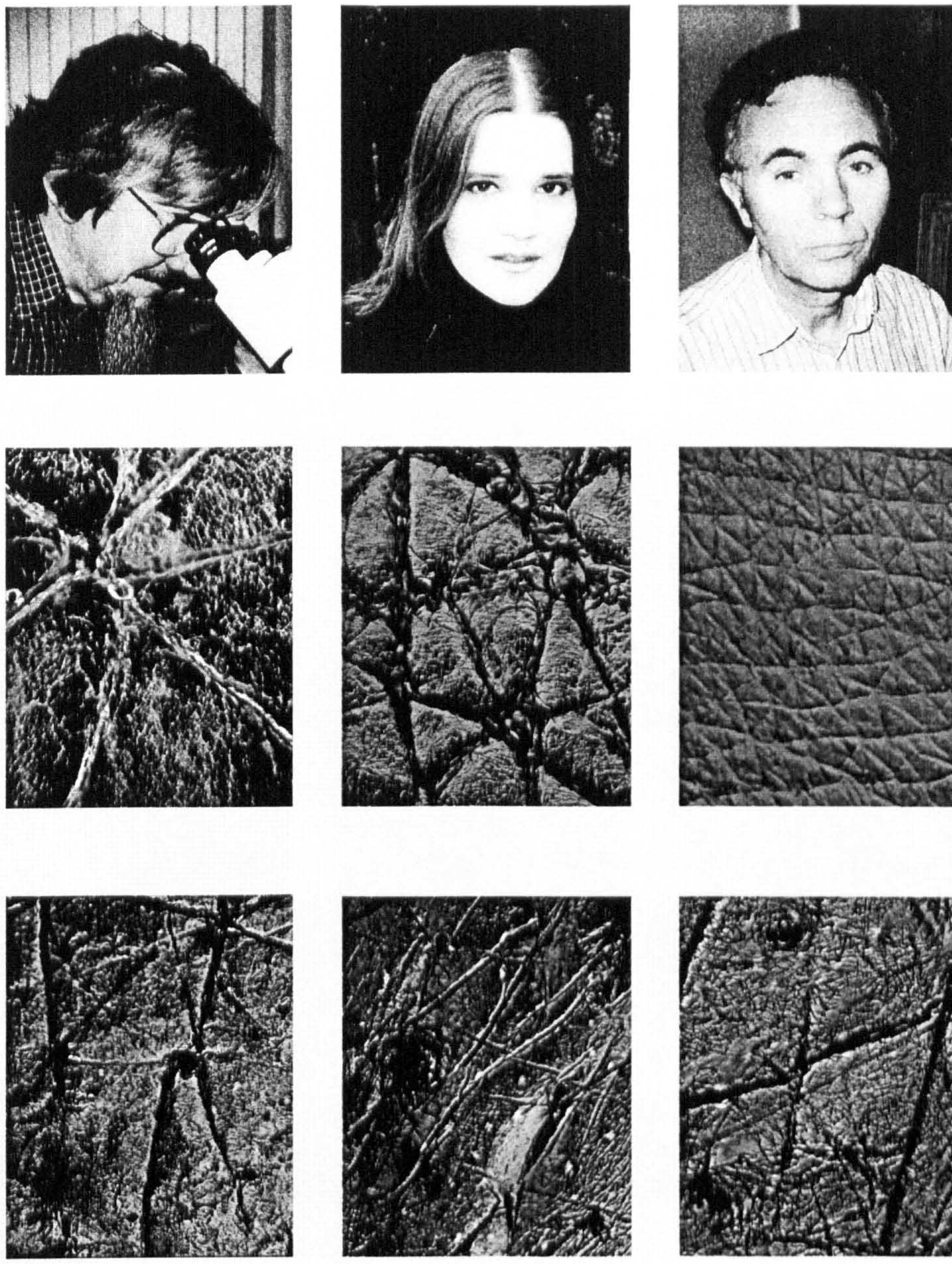
#S3 Forehead
High magnification.

Donor: JUNKO
Female, 25 years, Japanese.
Polaroid photo.

#S23 Forearm
Low magnification.

#S8 Forehead
Medium magnification.

145 'Topography' of skin. Light microscopy.
Skin donors and comparative studies of their skin surface showing typical drawings of microrelieves from negative replicas of the dermis.



Donor: KLAUS
Male, 50 years, German.
Polaroid photo.

#S47 Forearm
High magnification.

#S7 Forehead
Medium magnification.

Donor: ZANE
Female, 30 years, Latvian.
Polaroid photo.

#S58 Forearm
High magnification.

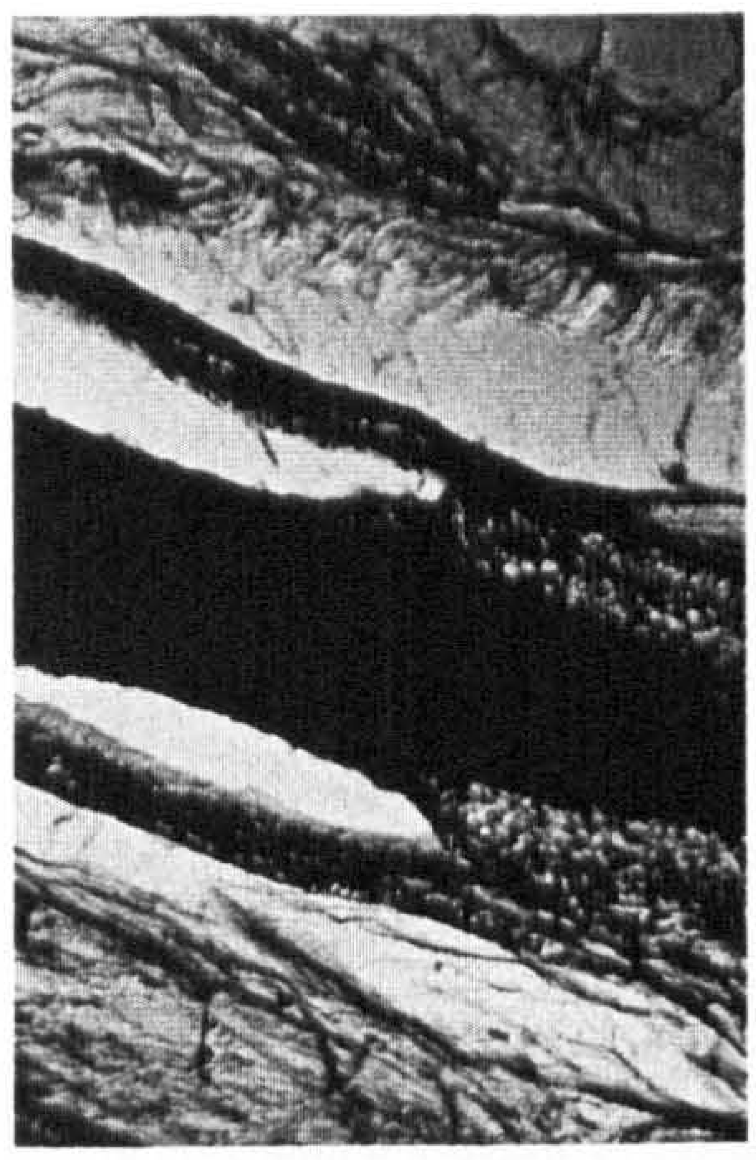
#S14 Forehead
High magnification.

Donor: RICCARDO
Male, 59 years, Italian.
Polaroid photo.

#S19 Forearm
Low magnification.

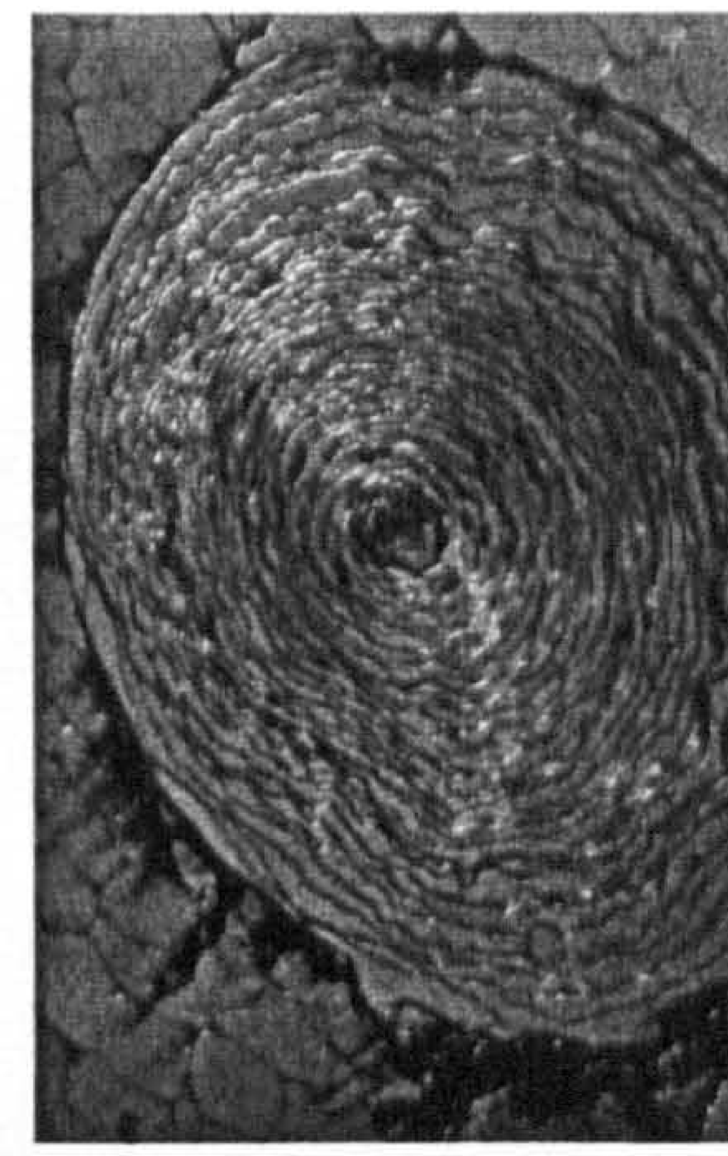
#S11 Forehead
High magnification.

146 'Topography' of skin. Light microscopy.
Skin donors and comparative studies of their skin surface showing typical drawings of microrelieves from negative replicas of the dermis.

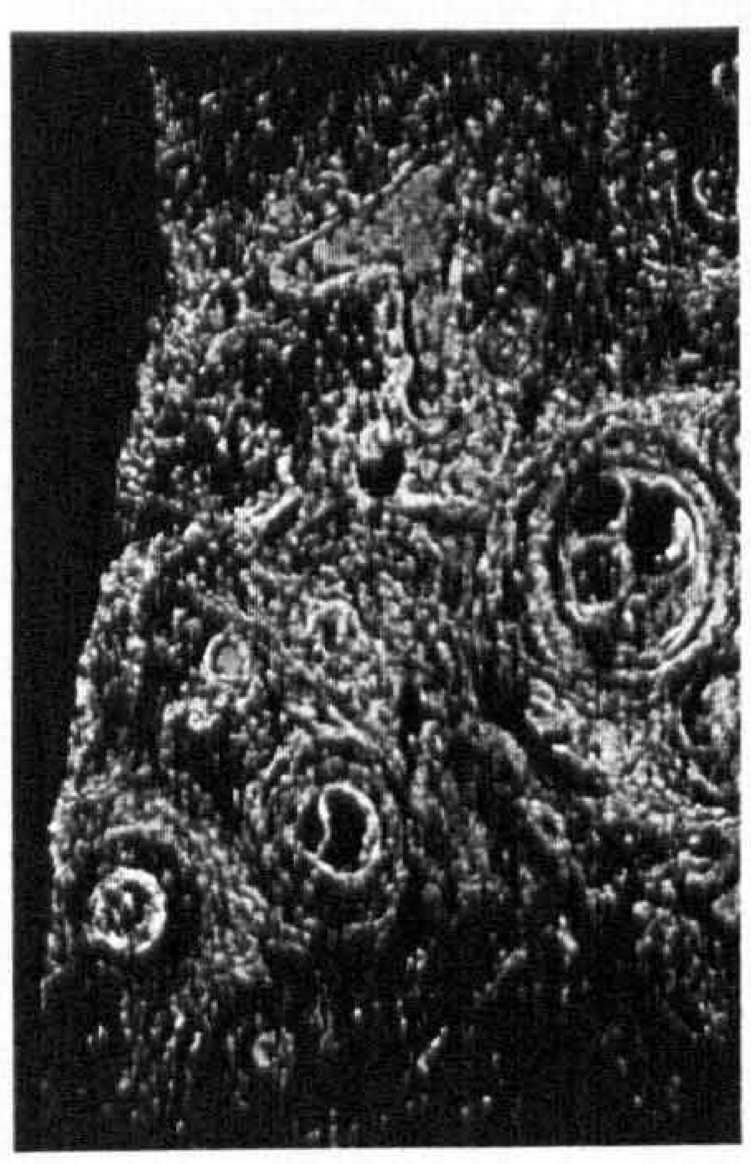


147 A

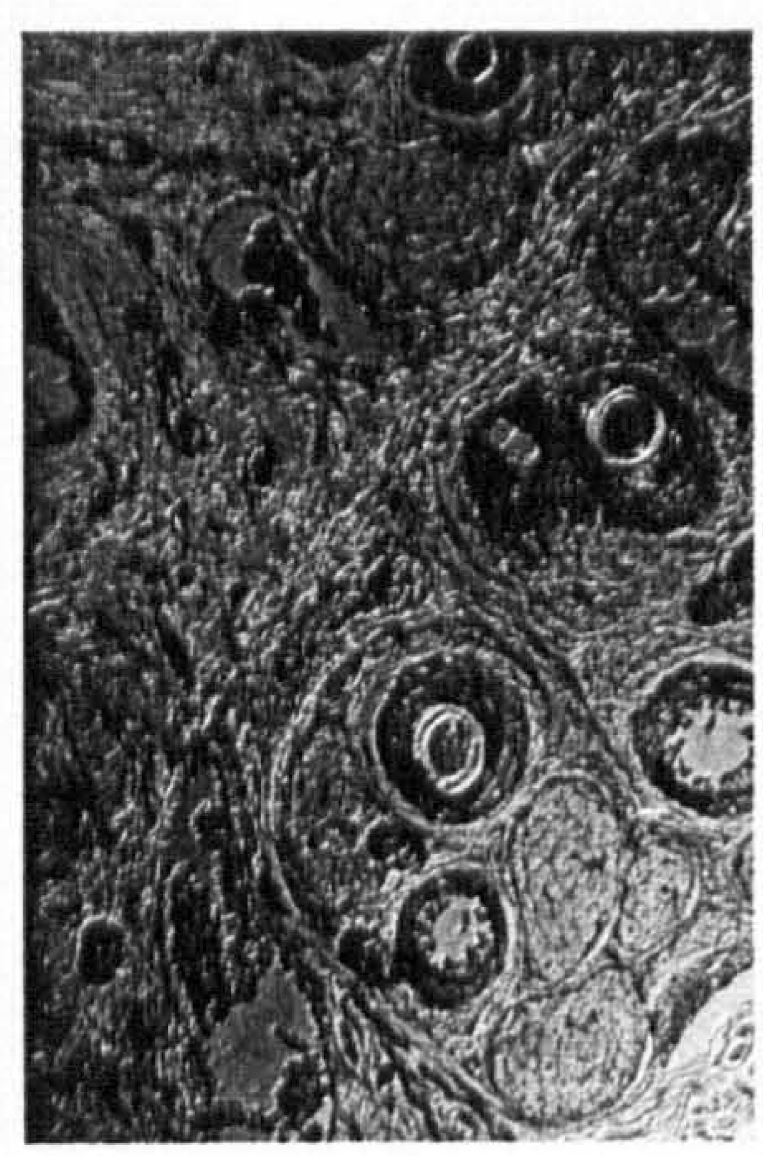
147 B



147 C

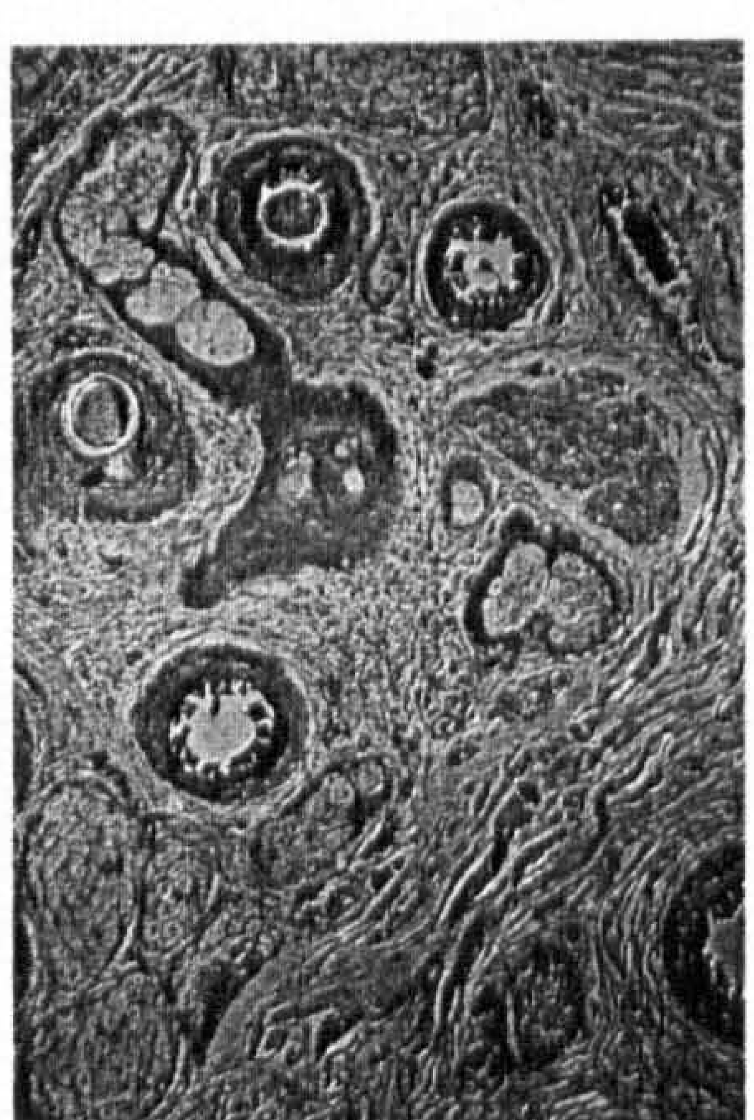


147 D

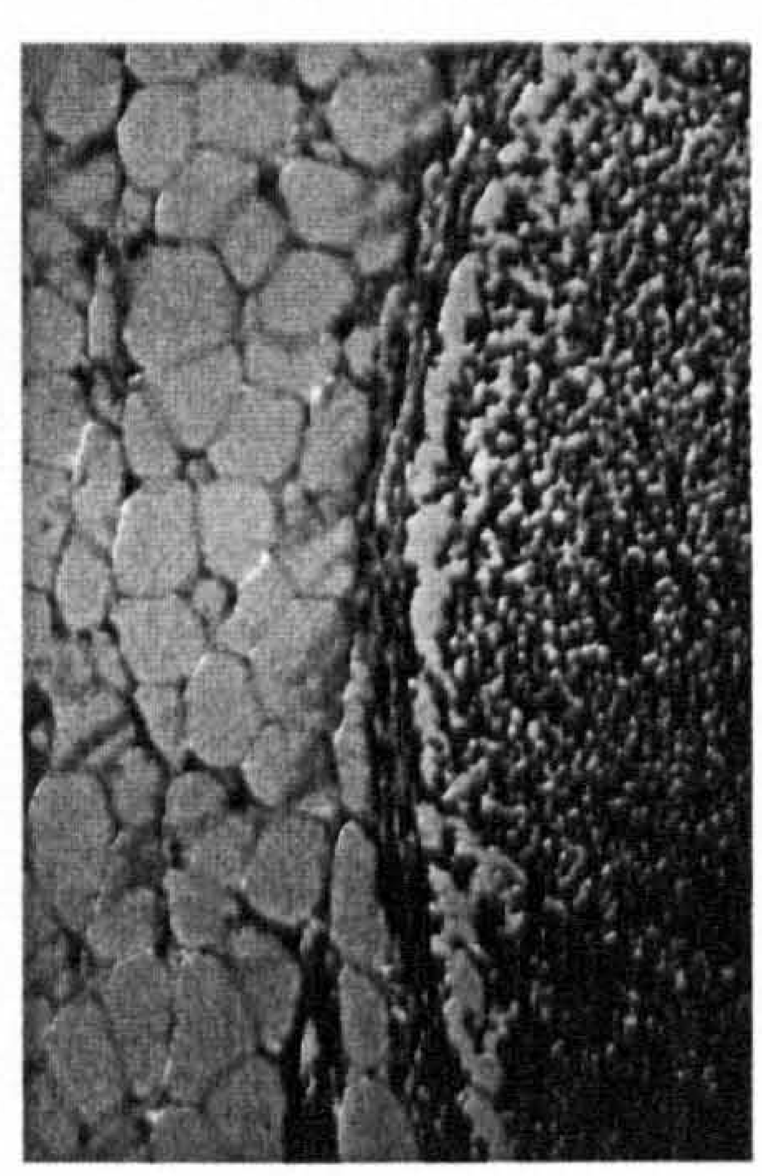


147 E

147 F



147 G



147 H

147 A = #A11, scalp, hair insertion, VS.

147 B = #A28, scalp, hair insertion, HS.

147 C = #A17, scalp, Pacinian corpuscle, VS.

147 D = #A27skin, HS.

Blackfield micrograph.

147 E = #A30, scalp, TS

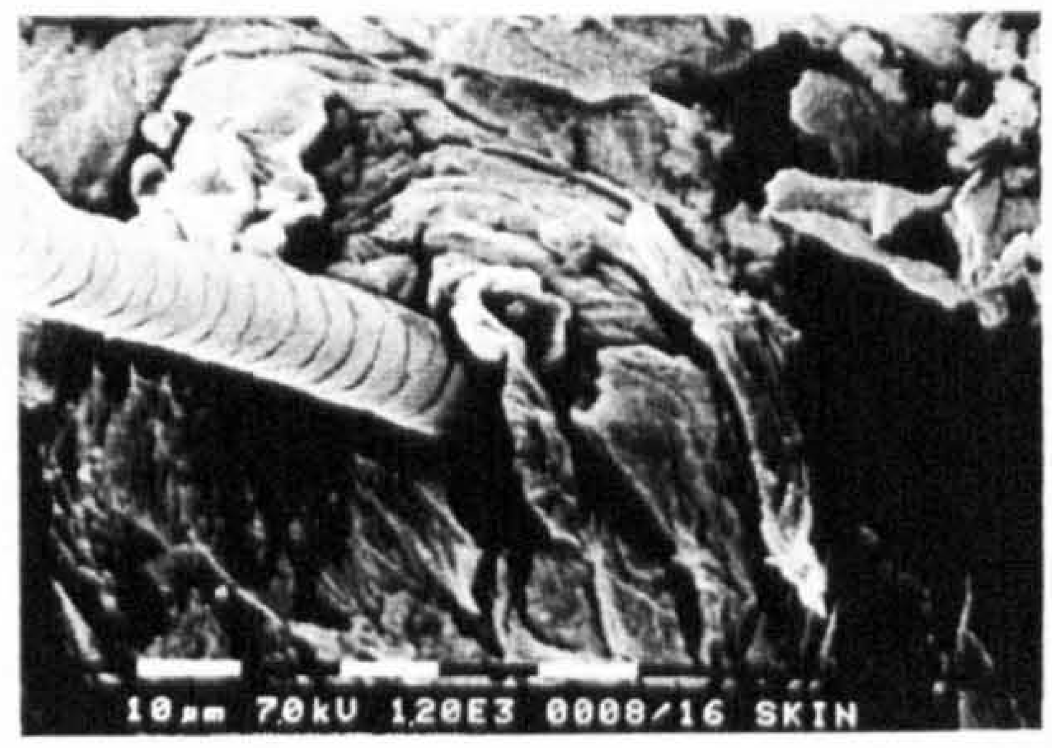
147 F = #A24, scalp, hair insertion, VS.

147 G = #A20, skin, HS

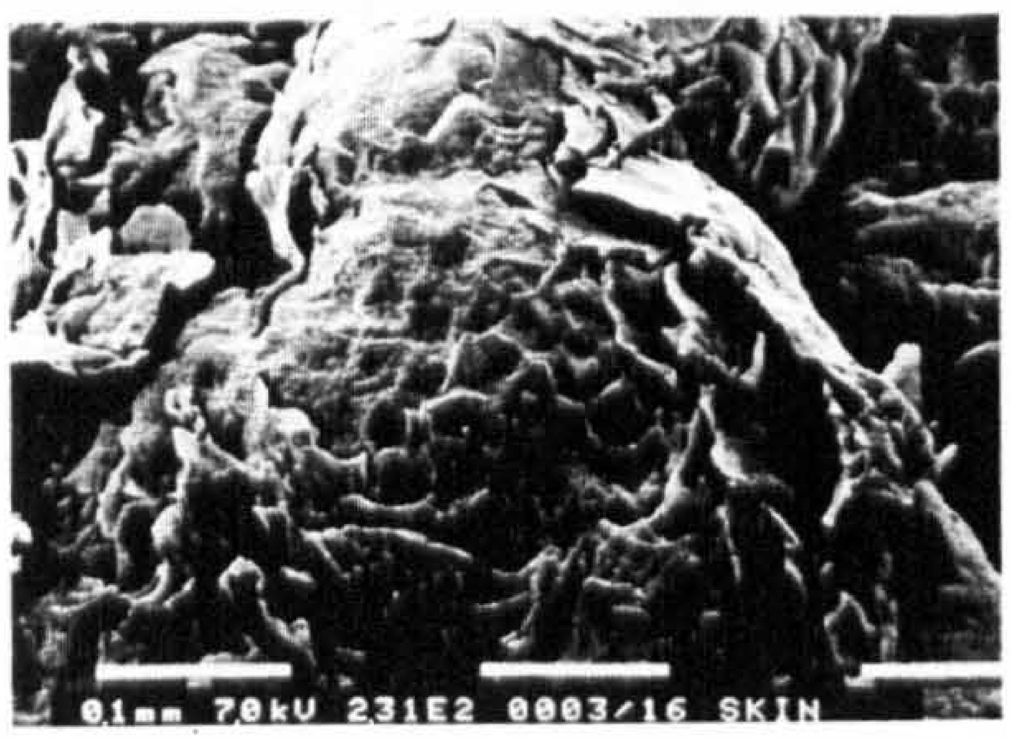
147 H = #A12, scalp, HS

147 'Architecture' of skin.
Micrographs obtained using chemically preserved human skin tissue.
Light microscopy. VS = vertical section, TS = trans-section, HS = horizontal section.

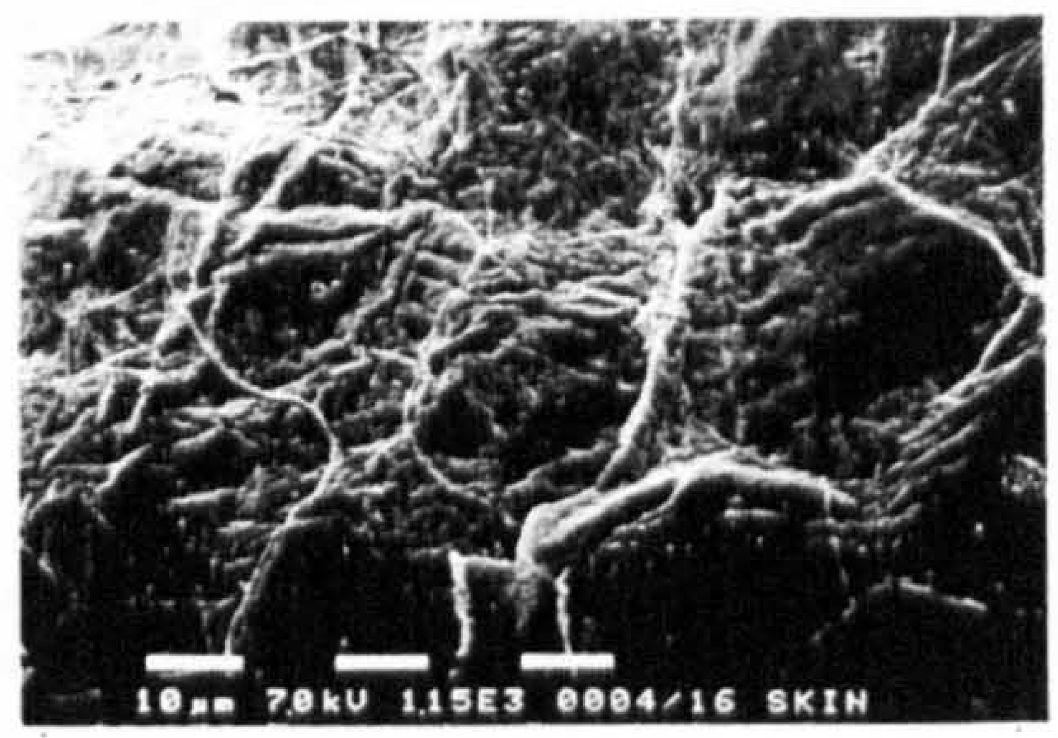
148 A



148 B

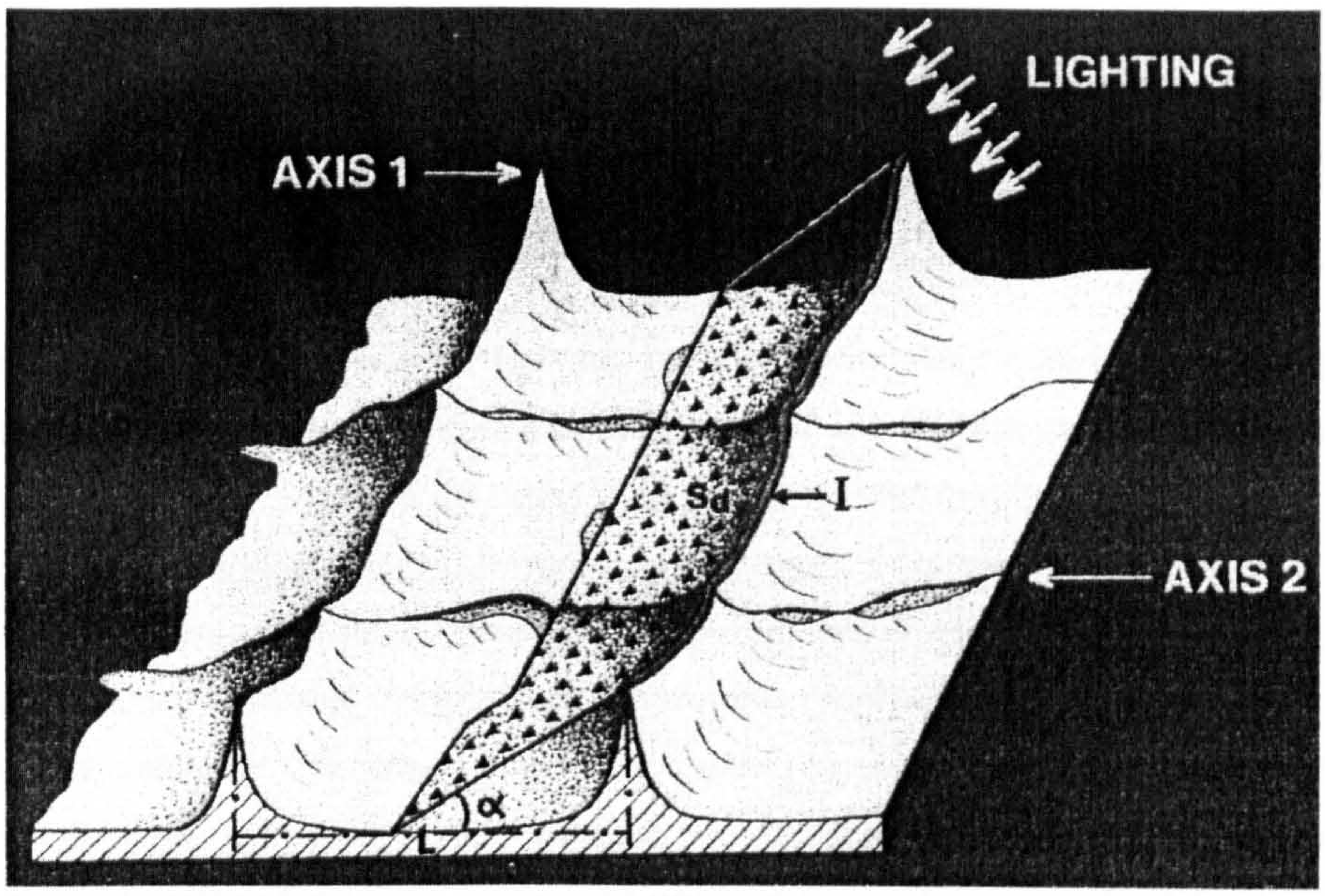


149 A



149 B

Zoom-in. 'Architecture' of skin. Micrographs of skin tissue taken using a scanning electron microscope.
148 A, B Close ups of hair insertion. Various magnifications.
149 A, B Close ups of keratinized epidermal cells. Various magnifications.



150

150 The shadowing principle applied on a skin surface model, originally developed by NASA to study lunar topography. In dermatology it is used in image analysis: a = incident light angle; Sd = surface area of shadows; I = intercept length.

08.5 SCIENTIFIC IMAGING: CAN I TRUST MY OWN EYES?

'With the aid of microscope you can see the surface of the objects. It magnifies them but does not show the reality. [...] Do not even think that you are seeing the things themselves.'[8] ***Feng-Schen Yin-Te (1798)***

The photomicrographs taken for scientific purposes often differ from those taken by an artist in their expression and manner, despite the fact that the biological sample and the technology used are the same. Other than the fact that it is challenging to discover and to understand the complex arrangements of human skin tissue, as a designer I was also interested in using high-tech magnifying facilities as a specific tool, for making aesthetic decisions on the pictorial representation of a particular biological specimen. The image is typically created by varying the conditions of light, changing lenses used and manipulating the final representation according to subjective aesthetic convictions. This might lead one to question the reliability of the scientific visual information, but the photomicrographs produced during this research are not simply a beautiful by-product of the research, they all contain scientific information per se.

Martin Kemp, a historian of art and science comments on this matter by saying that all representations, not just the imagery produced by scientific techniques, by definition have an element of artistry. 'Whether we are dealing with an artist making a detailed rendering, a photographer who judges lightning, exposures and printing, or a technician adjusting the emission and parameters of the receiver in an ultrasound scan, complex series of choices are made, which involve what we may call artistry, in the sense of using skill to give a selective, effective and even appealing depiction.'[9]

Despite its scientific origin, the microscope has relatively little to do with so-called 'objective reality'. It magnifies structures within the object but it does not necessarily show the 'truth', as the visual information becomes decontextualised and therefore, creates an abstraction. Artist Rebecca Birch, who has used the microscope in her creative practice, reflects on her experiences: 'The microscope allows one to see beyond the limits of sight, and into the heart of the space. While looking through the microscope, one is disembodied, becoming nothing but an eye. The microscope actually does not reveal anything except the illusion.'[10]

CHAPTER 09 ::

PRACTICE STEP II
DESIGNING ASPECTS OF THE TEXTILES

09 PRACTICE STEP II - DESIGNING ASPECTS OF THE TEXTILES

In order to co-ordinate the progress and production of experimental mixed-media textile samples adequately according to the established research aims, an overall formal scheme containing the main design aspects, such as analogies, sources, methods, materials, technologies and realisation has been developed as seen in Table 5. Another scheme (Table 6) features in more detail a system developed for the translation of the identified skin-like properties into a textiles vocabulary. The skin qualities have been divided into three categories, namely: in 'memory & identity', 'sensor & communicator' and 'protection & comfort' that all are correspondingly addressed in my textiles interpretations.

Both schemes are based on the information derived from the previous studies on skin tissue, with the main objective being the proposed outcome of the practice led research. Interactive and responsive textile surfaces for the body and the environment, respectively for the 2nd and 3rd skin, were intended to be created through the utilisation of different technologies and properties of certain materials, by putting them together in experimental and innovative combinations. These materials and technologies are described in Chapter 10.

DESIGNING PRINCIPLES

Design	Surface & Pattern	Form & Construction	Function & Interactivity
Analogy	based on skin's 'topography', its surface structure, magnified skin patterns	based on skin's 'architecture', structures of its cross-sections, vertical and horizontal sections, and its three-dimensionality	based on skin's 'technology', its properties and functions divided into: 'memory & identity', 'sensory & communicator', 'protection & comfort' *
Source	skin biology: scientific imagery, scientific drawings, theory		
Materials	variety of industrial nonwovens, latex, silicone, resins, silk, bonding materials, flock transfer print films, metallized transfer films, special thermoplastic adhesive webs and various printing inks, thermochromic inks, conductive materials, microencapsulated fragrances, phase change materials, freshness and deodorising finishes, anti-bacterial and anti-microbial materials		
Technologies	silk screen printing, heat transfer printing, digital printing, layering, bonding, coating, stiffening, baking, dye-ing, 3D moulding, black and white photography transfer, electronics		
Realisation	experimental & technical textile samples and three-dimensional model making in order to produce functional textile surfaces that: • mimic the physical and aesthetic qualities of the skin • respond to body temperatures and/or fluctuating room temperatures by changing colour • release odours and therapeutic oils • absorb malodour in the room and/or have anti-bacterial and anti-microbial sytems incorporated • act as thermo-regulators in a living environment • act as electro-magnetic shielding • respond to electrical stimuli by changing colour or by showing up latent patterns or by releasing aromatherapeutic oils		

Table 5
Designing principles used for the development of the textile prototypes.
* see Table 6.

(RE)WORKING THE SKIN THROUGH THE MEDIUM OF TEXTILES

Smart interface between external and internal worlds

MEMORY & IDENTITY	SENSOR & COMMUNICATOR	PROTECTION & COMFORT
Skin as a complex genetic and social display	**Skin as a responsive and interactive membane**	**Skin as a barrier and exchange for comfort**
Epidermis, Dermis, Subcutis » **Surface, structure & colour »** Mirror of physical and mental health, person's social status and values » also mirror of social context, society's trends and values, development of medicine and science. **History of skin »** **Injuries** bruises, wounds, scars **Deformities** wrinkles, dark or light spots, unwanted hair, moles, pigmented moles, warts **Ailments/Infections** pimples, furuncles, abscesses, eczema **Mechanical interference** tattoos, branding, cuts, surgery, plastic surgery	**Epidermis, Dermis, Subcutis »** Biological control and response capacity (sensory receptors & nerve bundles & blood vessels & smell-producing sweat glands). Through the interwoven meshwork of a connective tissue of proteins called collagen and elastin are running blood vessels, lymph vessels, nerve endings and fibroblasts. Specialised nerve endings enable us to feel pain, heat, cold, preasure and the surfaces or substances we touch. The information collected from the outer world is first sent to the brain by electric impulses. Rich blood supply provides nutrients and energy to both the dermis and epidermis. Surface capillaries can open in warm weather or when we are excited (vaso-dilation) to flush the skin surface with blood, assisting cooling, or close in cold weather (vaso-constriction), restricting blood flow and conserving heat. *Apocrinre* sweat glands (they open into associated hair follicles) are innervated by the sympathetic nervous system and produce chemical substances releasing odours called pheromones - our very specific biological odour signature.	**Epidermis, Dermis, Subcutis »** Immonological surveillance system, biological barrier and mechanism for thermo-regulation. Skin is waterproof, so it prevents water entry to, or loss from, the body. It prevents the entry of harmful bacteria and viruses as well as produces the pigment melanin, which protects the body from the harmful ultraviolet component of sunlight. Skin is a self-healing, self-repairing and antimicrobial mechanism. Skin is a temperature regulator, sweating assists heat loss by the evaporation of perspiration from the skin surface. *Eccrine* sweat glands are innervated by the sympathetic nervous system, they respond to temperature increasing their output of salty water when the body becomes hot. Also blood circulation helps to maintain the right body temperature. The fat layer under the skin provides heat insulation.
Textiles » Textiles mimicing structure and aesthetic qualities of skin inspired by scientific representations of skin such as drawings and micrographs taken using light microscope and electron microscope, as well as by my observations of various conditions of skin.	**Textiles »** Indicators of fluctuating environment conditions depending on the ambient or external heat by changing colour » Interactive and decorative potentional of heat sensitive surfaces » transient or latent skin images and patterns showing up as a response to certain stimuli » odour signature surfaces » therapeutic surfaces.	**Textiles »** Textiles as latent heating systems » electro-magnetic shielding » antimicrobial, curative and malodour obsorbing surfaces to enhance people's well-being and health.

Table 6
(Re)working the skin through the medium of textiles.

CHAPTER 10 ::

MATERIALS AND TECHNOLOGIES

10 MATERIALS AND TECHNOLOGIES

'Every material has both technical and aesthetic properties. It has to satisfy constructional, physical and sensory requirements, and it can be required to meet social demands such as safety and environment-friendliness. Everybody reacts differently to a material, and the experience it offers can be a highly personal one.'[1] ***Els Zijlstra / Materia***

In order to carry out experimental work, certain materials had to be considered and obtained. The principal materials required were: cloths of different construction and of different fibre type, some with specific engineered functions incorporated (10.1), materials for bonding and lamination (10.2), chromatic materials (10.4), materials with aroma release and freshness technologies incorporated (10.5), phase change materials (10.6), conductive materials (10.7), stiffening materials (10.8), electronics and electrical devises (10.11) and other materials (10.9). Surface design technologies are featured in 10.10. The characteristics of the material properties and technologies involved in my practice led research work are described below.

10.1 FABRICS

Different types of spunlaid nonwovens were used to produce textile samples because of their structural skin-like qualities. The fibres in spunlaid nonwovens form a random three-dimensional structure which makes strong references to the collagen-elastin grid forming the skin.

Nonwoven Colback®, in different qualities (WF30, WF50, WF120) was used. Manufactured by Colbond Nonwovens in the Netherlands, the main applications of Colback® are in flooring and the automotive and construction industries. It is a thermally bonded example of a spunlaid fleece, made from biocomponent filaments with a polyester core and polyamide skin, to form a random structure. The process allows the non-woven to create a unique pattern, which forms its unusual three-dimensional structure and is unrepeated. The filament structure is as unique as a fingerprint. There are applications of Colback® fleece in the manufacture of identification cards incorporating the non-woven as an authentication tag in place of a magnetic strip, which makes the card fraud proof according to the company's claims.[2] Colback® is ideal for dyeing using direct dyes (Sirius provided by Bayer), as well as for heat transfer printing, also called dry dyeing, employing disperse inks (Deka provided by Deka Textilfarben GmbH). It has good thermo-plastic properties for three-dimensional moulding.

Other types of spunlaid nonwovens used include PINK VIBRAtex® type B4 and ORION® TM type DU 025 manufactured by CEREX Advanced Fabrics in the USA and distributed by CELL International in Europe. Because the fabrics are made of nylon, both nonwovens have high tensile and tear strength even at low fabric weights. In addition, nylon bonds well with all adhesive systems making these fabrics excellent materials for manufacturing laminate and composite systems. VIBRAtex® products are chemically bonded nonwoven nylon fabrics available in custom colours. The colouring of the nonwoven is achieved by encapsulating the colours in the fibres and is therefore less likely to bleach, fade or wash out of the fabric. ORION® nonwoven is a nylon fabric thermally bonded with a diamond bond pattern.

White polyester spunlaid nonwoven was obtained from the distributor Zijdelings in Holland. It is excellent for heat transfer printing purposes and it has good thermoplastic qualities. Another nonwoven employed was DROP SCREEN PAPER® from Procédés Chénel. This material combines dense paper-like quality with the tear strength and tensile qualities of a fabric. It is composed of cellulose, polyester, glass fibres and adhesives and is flame retardant material, classified as B1/ DIN 4102. And finally, a thick polyester fleece, typically used for the linings of winter clothes and available in every fabric shop, was also employed.

Woven 100% cottons and woven 100% silks were used. Additionally, crêpe silk made of S-warp and Z-weft (S and Z – twist direction) was used in order to obtain specific three-dimensional surface pattern due to the natural shrinkage of the fabric after washing. Some nylon fabrics including tulle were also used. Nylon, cotton and silk were purchased from Cloth House, London.

10.2 BONDING AND LAMINATING MATERIALS

For bonding two or more layers of different fabrics together, special thermoplastic adhesive webs, which can be activated by heat, were used. They were also found to be useful for special surface design effects in combination with metallized transfer films or flock transfer print films. Marketed under the SPUNFAB® trade name, the industrial adhesive webs are manufactured by Hänsel Verbundtechnik. SPUNFAB® webs consist of adhesive mono-filaments in the shape of thermally bound random or parallel pattern nonwovens. The advantages of composite materials made by applying webs include excellent bond strength values even with low adhesive weights, no full-surface adhesion and therefore openness of the structure, excellent permeability values, flexible handling and high elasticity. For textile samples SUNFAB® in the following qualities was used: PA 1541, PE 2900, SL 7001 and ABA 001.

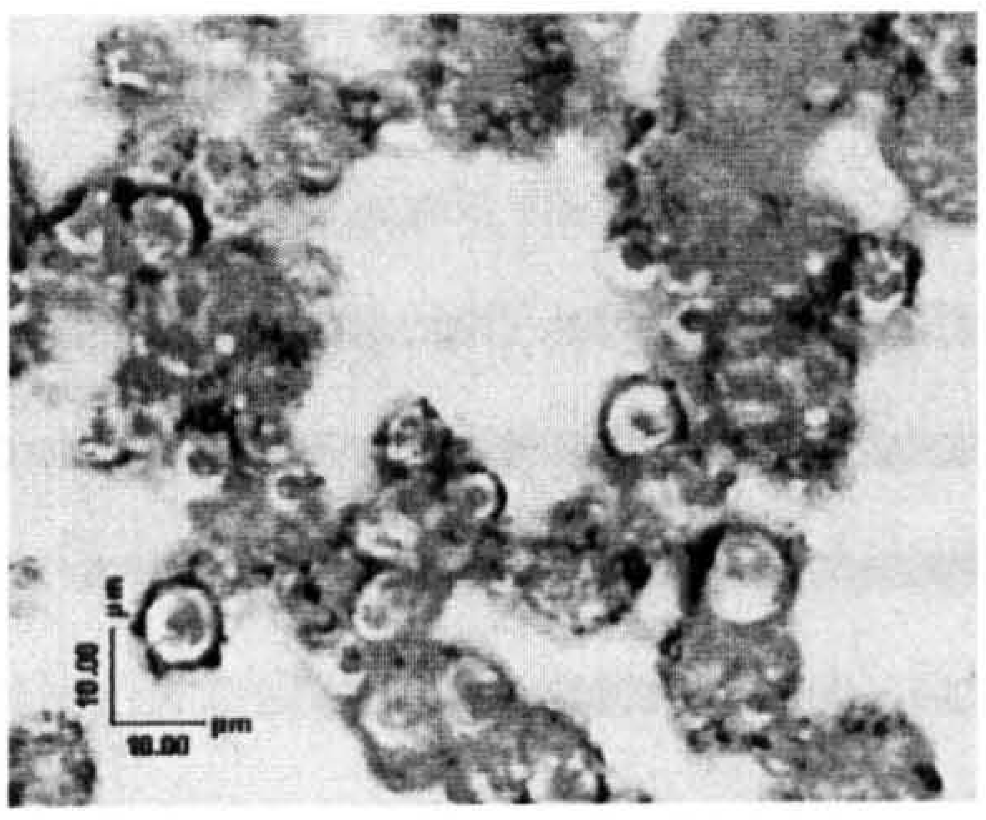
For the coating and lamination of the fabrics technical thermo-adhesive film IR type T2 was employed supplied by the company PROCHIMIR. This transparent thermoplastic film has good respiratory properties and therefore can be used both for applications in interiors and for clothing. In some cases Kyrell and Epson ink jet transfer foils were applied with pre-printed digitally manipulated skin surface patterns. These films also provide a barrier function against abrasion and liquids, however they do not allow the fabric to breath.

10.3 MICROENCAPSULATION

Several technologies employed during my research project, which are described below in this chapter, are based on microencapsulation technology (thermochromatic materials (10.4), materials with aroma release and freshness technologies incorporated (10.5) and phase change materials (10.6)). Therefore a short introduction to microencapsulation technologies is given.

The concept of 'microcapsule' was started by the DDS (Drug Delivery System) in the 1940's and later applied to pressure sensitive or carbonless copy papers by the National Cash Register Company (NCR) in the USA in the 1950's. This was the first commercially viable microencapsulation process, based on the so called coacervation method. The complex coacervation is known to work well in the microencapsulation of solids and oily materials.[3,4]

Micro-encapsulation is a process in which microscopic droplets or particles are surrounded by a protective polymeric coating, which results in the production of tiny capsules with many useful properties. Micro-encapsulation provides a miniature container that protects its contents from evaporation, oxidation and contamination until its release is triggered. For most applications the capsule diameters are in the range of between 1-50 microns (one micron = one thousandth of a millimetre) but depending upon the particular manufacturing process which is employed, it is possible to produce microcapsules with diameters ranging from a few microns to a few millimetres.[5] The size is always tailored to suit the end product. According to the preparation method nearly ideal core/shell structures or spongy-porous structures can be obtained.[6]



151 A light micrograph of microencapsulated lavender oil. The microcapsules seen in this image are around 10 microns small.

The capsules are so tiny that they remain invisible to the naked eye, yet high power microscopes open up an exciting insight into this curious dimension. For example, an area of one square centimetre could contain approximately one million capsules placed side by side.

According to the Korean Research Institute J&C microchem, Inc.[7], microencapsulation technology provides the following useful functions:

- converts liquids into solid particles
- protects unstable substances in a particular environment (heat, pH, etc.)
- increases duration by controlling the release speed of core material
- locates a substance to a certain place
- minimises loss during manufacturing process
- stirs reactive substances together
- enables easy handling of toxic or irritable substances and substances that can be destroyed easily
- offers a variety of functions that can be obtained by changing the core material and/or wall material
- due to the technology systems can be designed that release the content on a certain process if necessary

Microencapsulation techniques have been researched and advanced in various fields and it has been made possible to develop various products by using these processes. Therefore microencapsulation of materials proves to be a very useful tool for a large number of industries, ranging from food and pharmaceutical industries to colour chemistry industries.

10.4 CHROMATIC MATERIALS

Chromic materials in particular have raised the interest of designers because of their surprising and optically pleasing nature. They change their colour reversibly according to external environmental conditions, and for this reason they are also called 'chameleon' materials. Chromic materials is the general term referring to materials, which change colour because of induction caused by external stimuli.

Chromic materials are classified depending on the stimuli affecting them[8]:

Phenomenon	External Stimuli Energy
1. photochromic	light
2. thermochromic	heat
3. electrochromic	electricity
4. piezorochromic	pressure
5. solvatechromic	liquid
6. carsolchromic	electron beam

Table 7
List of chromic materials depending on the external stimuli affecting them.

For the production of experimental textile samples thermochromic and photochromic materials were used. Their properties are described below.

10.4.1 PHOTOCHROMY

The phenomenon produced in photochromic materials is called photochromism, where the change in colour is due to conditions of light. However, to date, photochromism is mostly used for optical switching data and imaging systems, rather than for textile applications. It is possible to classify photochromic materials into two groups[9]:

- those, which emit colour when activated by visible light
- those, which emit colour when activated by ultraviolet radiation

Some companies offer special photochromic printing inks for textiles applications called 'Sun-Reactive' or 'Light-Sensitive' colourchange inks. They are colourless in dim light but when exposed to sunlight or other UV light source, they become brightly coloured. They fade back to a colourless state once they are removed from the source of irradiation. Within the UK, the company James Robinson Ltd is a manufacturer of such dyes and coatings. They offer a large range of photochromic dyes, with a wide range of colours and a choice of activation and fade kinetics under the trade name REVERSACOL.[10]

There are also other types of photochromic materials, which emit fluorescent colours, typically red, green or blue under ultraviolet light in a dark environment, yet maintain their original colour when exposed to natural light.

Other photochromic materials have pigments applied that can store light. Most commonly these are used for safety reasons. The working clothes for road workers in bad lightning conditions or the marking of carpets and walls to guide people during power failures would be typical examples of this. Some experiments using phosphorescent materials (COLORMATCH PH 451 pigments by CHT Beitlich GmbH and photoluminescent yarns by Permalight AG) were conducted during my research project in order to address the psychological metaphor of radiant and glowing skin conditions signalling happiness and wellbeing (see Fig. 203).

10.4.2 THERMOCHROMY

Thermochromic materials also belong to the chromic materials group. Thermochromic materials are those whose colour change effect happens in response to temperature fluctuations. By increasing or decreasing the temperature, it is possible to initiate the colourchange from one colour to another, or from colour to colourless. The reversible colour change can be initiated over various temperature ranges depending on the pre-designed material properties.

There are two types of thermochromic systems that have been used in textiles: the liquid crystal type and the molecular rearrangement type. In both cases, the dyes are embedded in microcapsules, and applied to the fabric as a pigment in a resin binder.[11] It is possible to make visible 'hidden images' or 'hidden messages' by employing these inks and this quality was explored in my practice.

10.4.2.1 THERMOCHROMIC LIQUID CRYSTAL (TLC) TECHNOLOGY

'The term 'liquid crystal' was first used by the German physicist Otto Lehmann in 1889 and has remained in use since as it describes so well the properties of the mesomorphic state, i.e., having the mechanical properties of liquids combined with the optical properties of crystals.'[12]

The most important types of liquid crystals for thermochromic systems are the so-called cholesteric types.[13] Cholesteric liquid crystals have a spontaneously twisted nuclear structure, which can be made to expand and contract as the temperature changes. Light is reflected by this structure and as it twists and untwists the colour of the reflected light changes.[14] 'The cholestic liquid crystal effectively behaves as a sophisticated mirror which can reflect specific wavelengths of light [...]. Therefore, if the light which is transmitted through the liquid crystal is absorbed by a black background, the reflected wavelengths of light are observed as pure iridescent colour.'[15]

From the aesthetic point of view this technology is very impressive and optically remarkable because of its property to display bright iridescent colours. TLC's colour-play starts black below the temperature range, goes through the colours of the rainbow, starting at red and finishing at blue, and then back to black again above the temperature range. TLC's are reversible in that they can be used over and over again. Thermochromic liquid crystals can be formulated to change colour from approximately –30°C to +290°C (–30°C to +130°C approximately, for printing inks). Moreover, the temperature response point can be tightly engineered and can be sensitive enough to detect changes as small as 0,5°C.[16]

Some applications of thermochromic liquid crystals include[17]:

- thermometers for the home or office, forehead temperature strips for sleeping children or postoperative patients who are still under anaesthetic to give a good indication of the core body temperature
- medical thermography, for assistance in the identification of a wide range of medical conditions, such as detection of breast cancer and the location of the placenta of an unborn child
- non-destructive testing of structural materials and components for thermal mapping of inanimate objects, which provide engineers with useful diagnostic and design information because of the ability of TLC to map small temperature gradients
- applications in microelectronics for the detection of faults, including short circuits, poor electrical joints, overheating due to design or construction errors, and areas of circuitry which are inoperative

- decorative and novelty items, to draw attention to a particular product or for fashion applications

The company Merck has been developing this technology for textile applications in the form of printing inks. New Scientist Magazine on the 11th of May 1991 comments on this: 'Chemists have added a new dimension to the revival in sixties 'psychedelia' by developing materials that change colour when they change temperature. [...] The chemists at Merck have been working for 10 years on liquid crystal materials which are best known for their use in the displays of watches, pocket televisions and portable computers.'[18] However, when I contacted Merck in 2001, they informed me that the research and production of thermochromic printing inks under the trade name LICRITHERM had terminated due to high costs.[19] Currently the only commercially available TLC inks in Europe are produced by Hallcrest Ltd, a company whose first involvement in the thermochromic liquid crystal industry is dated back to 1974.[20]

The temperature-sensitive liquid crystals colourchange play is visible when applied over a dark, ideally black, background. Printing onto a black substrate or background therefore introduces some limiting design constraints, which hinder the commercial use of these inks. Moreover, in order to establish liquid crystal materials in our everyday life, it is necessary to improve their resistance to UV light and their durability against strong solvents and high temperatures, which cause irreversible changes in the TLC's molecular structure. Unfortunately, current technologies have been unable to effectively prevent this.

Some experiments using Thermochromic Liquid Crystal C22-27 series inks supplied by Hallcrest Ltd were carried out (see Fig. 237, 271). However, due to their high cost and vulnerability to UV light no further developments were undertaken, apart from the use of TLC coated polyester sheets, also manufactured by Hallcrest Ltd.

10.4.2.2 THERMOCHROMIC MOLECULAR REARRANGEMENT TECHNOLOGY

An alternative method of inducing thermochromism is by means of a rearrangement of the molecular structure of a dye, as a result of a change in temperature. The most common types of dye, which exhibit thermochromism through molecular rearrangement are the so called spirolactones, although other types have also been identified. A colourless dye precursor and a colour developer are both dissolved in an organic solvent. The solution is then microencapsulated, and is solid at lower temperatures. Upon heating, at the melting point of the mixture when exceeding a certain temperature or so called activation temperature, the system becomes coloured or loses colour. The reverse change occurs at this temperature upon cooling, or the colour changes back and forth as the temperature fluctuates.[21] Thermochromic molecular rearrangement technology can be formulated to change colour over temperatures ranging from –5°C up to about +60°C. The temperature response point is not as sensitive as that of TLC's, it takes about a 3-5°C temperature change to detect a corresponding colourchange.'

When working with these inks it is important to note that the base colour of the substrate to which thermocromic inks shall be applied has to be recognisably lighter than the thermochromic ink itself, in order to view the colourchange effect. It is also possible to mix the thermochromic ink with an additional ordinary textile pigment in order to obtain various colour shades. For example, blue thermocromic ink + yellow pigment printed on a white background results in a green print in lower temperatures and in a yellow print in higher temperatures after the colourchange has taken place.

Thermochromism through molecular rearrangement in dyes has provoked a degree of commercial interest, for several reasons:

- it is a more competitive thermochromic technology with relation to price when compared to TLC technology
- it is relatively UV light stable
- the overall mechanism underlying the changes in colour is more stable compared to the relatively fragile TLC technology
- even though the technology is less precise and more robust compared to TLC and cannot be controlled that well as liquid crystals, thermochromic molecular rearrangement technology can be used in a wider range of inks and plastics. Currently it is commonly used for several novelty applications, Duracell® battery testers, food labelling, Jack® microwave sensors and toys

For the experimental samples of this research project, CHROMICOLOR AQ inks from the company Matsui were used supplied by Cornelius Chemical Co. Ltd. The inks employed had different activation temperatures ranging from +20°C to +45°C.

10.5 AROMA RELEASE AND FRESHNESS TECHNOLOGIES

Textiles can provide a sensation of freshness and well-being by incorporating into their substances natural essential oils such as peppermint, grass, lemon-balm and lavender or synthetic essential oils, as well as specially designed fragrances. There are also methods of actively tackling bad smells and absorbing them, rather than masking them, to achieve an extra freshness. Such patented methods have been developed and are known as BREEZE® technology by the company Rotta GmbH (Chapter 10.5.3) and BaKaSave® technology by Bramberger Kaliko (Chapter 10.5.4). The aroma release and freshness technologies have been explored during my practise based textile experiments in order to incorporate references to the skin as an immunological surveillance and curative mechanism.

10.5.1 AROMATHERAPY

Aromatherapy is the very old art of using the healing powers of aromatic essential oils. Already thousands of years ago the ancient Egyptians, Romans and Greeks discovered the benefits of aromatic plants and this knowledge has been used effectively throughout the centuries.[22] Essential oils are extracted from organic plant sources, from flowers, leaves, seeds or the bark of trees. They are highly concentrated and contain therapeutic chemicals from the plants.

Essential oils can have many different effects on the body, mind and spirit. They can be sedative or stimulating, some have an antispasmodic effect, many are antibacterial. Basically, aromatherapy strengthens the self-healing processes by indirectly stimulating the body's biological defence system. Additionally, essential oils can aid in skin care and wound healing. Since ancient times, aromatherapy has been used as a form of medicine or for sensual purposes and it is still being used today.

Essential oils have been claimed to have the following benefits:

- dispersal of toxic build-up in muscles, reducing chronic tension
- stimulation of the lymphatic system and improvement of the blood circulation, bringing oxygen and nutrients to skin, muscles and essential organs
- stimulation or sedation (as required) of the central nervous system, to improve the performance of the body systems and enhance well-being
- action on the endocrine system, through the pituitary gland, stimulating hormone production and re-establishing balance
- promotion of a sense of physical and mental well-being, reducing stress and strengthening the body's defences

The aromas are perceived by the nerve endings at the back of the nose, and signals are passed to the limbic system, the hypothalamus, which governs the pituitary gland – the gland, which controls hormone release throughout the body. Additionally, production of different neuro-chemicals can be triggered by smells. Smells and fragrances can affect mood and emotions, they can uplift the spirit, clear the mind and relax the body.[23]

10.5.2 AROMA RELEASE IN TEXTILES

The integration of encapsulation technology in textiles offers an entirely unique range of new opportunities and product enhancement. The microencapsulation process enables millions of tiny capsules on an area of one square centimetre to contain a specific aroma for a virtually limitless time, until the surface is touched. This concentration allows for multiple releases from the same area until all of the capsules are broken. This can last for some years. Encapsulated fragrances can be applied onto textiles to enhance a garment, promote a product or mask an inherent malodour.[24]

Another method of activating the aroma released from the microcapsules is to stimulate it with a heat. At a certain pre-designed temperature the capsule's wall material starts to slightly change its structure by melting and delivering the core material scent. Upon a decrease in temperature, the capsule's wall material hardens and no aroma release is possible. This method has not yet been used in textiles applications.

Deodorising fragrances or malodour counteractants prevent the build-up of malodour during wear or use of the treated textiles and keep the textiles fresh when not in use. Deodorising fragrances operate via a number of mechanisms:

- inhibiting the enzymes responsible for producing malodour
- overwhelming the vapour pressure of the malodour
- reducing the perception of the malodour

Anti-bacterial and antimicrobial fragrances work by inhibiting the growth of odour causing bacteria.

Textile applications can be carried out by padding, spraying, printing and even by the rinse cycle of a washing machine. Wash durability is varied for each application, but can range from 5 – 30 washes at 40°C.[25]

For my practical experiments various printable ink pastes with encapsulated scents called AROMA® from the company Matsui, distributed by Cornelius Chemicals Co.

Ltd were used. After printing, the scents can be released by scratching or rubbing. Experiments with the aim of producing a printing ink for textiles, where the release of scent is triggered by heat, were also conducted. These were undertaken during a month's internship at the Fraunhofer Institute for Applied Polymer Research in Berlin, microencapsulating aromatic oils under the supervision of Dr. Rudolf Nastke. The oils were provided by companies Mercia International Fragrances and CPL Aromas.

10.5.3 BREEZE® – FRESHNESS TECHNOLOGY

New malodour absorbing technology by the company Rotta actively tackles malodour rather than masking it, to achieve an extra freshness in textiles. The manufacture claims that the finishing of textiles with the ROTTA-FRESH® system provides a double effect for the user[26]:

- absorption of smells by absorbing and storing unpleasant smells and releasing them during the next laundering cycle (smell protection)
- freshness function by storing conventionally applied perfumes or scents releasing them in dosages as and when there is a demand (e.g. sweating during sport activities) in order to keep textiles fresh for longer periods of time

The basic molecule for smell and scent absorption is cyclodextrin. Cyclodextrins are made by the chemical transformation of starch. They are able to form inclusion complexes with different kinds of guest molecules such as fragrances, sweat components, fatty smells, tobacco smoke components. There are several products designed by Rotta for cyclodextrin finishes on textiles: Smell Protection, Freshness Finish, Anti-Smell Finish and Odour-absorbing Finish.

The permanent fixation of ROTTA-FRESH® with special binders or resins on fabrics provides a good fastness to washing and dry cleaning for all kind of fibres and can be applied to textiles using several methods, such as by pad application, coating, printing and spraying method. This entire system is known on the market under the brand name BREEZE® by ROTTA and can be used for applications on garments (suits and dresses, sportswear, underwear, socks, linings), on home textiles (curtains, upholstery materials, bed linen, mattress duck) and on shoes (washable sports shoes, arch-support).

BREEZE® by ROTTA technology claims to have the following properties:

- permanent odour prevention and long lasting freshness
- it may be reactivated by washing at any time
- its function is always available
- it has anti-bacterial properties
- it is dermatologically and toxicologically acceptable
- it is fast to dry cleaning and washing up to 60°C
- it is biologically degradable

Compared with the systems which simply mask the malodour, BREEZE® by ROTTA technology provides odour absorption and it is renewable by simple home laundry. The BREEZE® finish was introduced into my practical experiments thanks to the kind support of Dr. Werner Volz from ROTTA (see Fig. 182).

10.5.4 BAKASAVE® TECHNOLOGY FOR CLEANER AIR

The BaKaSave® technology, currently used for roller blinds and vertical blinds, by Bramberger Kaliko, claims to obtain outstanding properties.[27] It contains a special substance, absorbing harmful gases and bad odours in the interior. It accumulates them at the surface of the fabric in a catalytic process, converting them completely into harmless matters like water (H2O) and carbon dioxide (CO2). Therefore the system never reaches saturation point, in contrast to the odour absorbents, which bind smells short term. BaKaSave® reduces harmful substances such as formaldehyde, ammonia and acetic acid and other toxins and absorbs nicotine and other unpleasant odours.

This is particularly important, as in most indoor spaces people are potentially exposed to the so-called Sick Building Syndrome. Hazardous emissions are continuously released into the air from building materials, furniture, floor coverings and consumer goods which may cause headaches, fatigue, skin rashes, eye irritation and respiratory problems.

The BaKaSave® system was used for my textile experiments in the form of special slurry and as ready-coated fabric substrates (see Fig. 183).

10.6 PHASE CHANGE TECHNOLOGY

Phase Change Materials (PCM) change their state of matter at a certain temperature: from liquid to solid and vice versa. For the applications in textiles, a special paraffin-like substance, set to a specific temperature, is used as a PCM, enclosed in tiny microcapsules. When the outside temperature rises, they store the excess heat. When the temperature falls again, they release the previously stored heat. Therefore PCM garments can keep the wearer warm when it is cold and cool when it is hot.

During the melting process, the temperature of the PCM as well as its surrounding area remains constant. The undesired temperature increase accompanying the normal heating process does not occur. The same is true for the crystallisation process. During the entire crystallisation process the temperature of the PCM does not change. The high heat transfer during the melting process, as well as during the crystallisation process without temperature change, makes PCM interesting as a source of heat storage. In textiles PCM-microcapsules can be permanently embedded in acrylic fibres or in polyurethane foams, or coated onto the surface of a textile substrate.[28,29]

Most of the PCM applications target the active-wear clothing sector. There, this technology has become particularly useful because of its capacity to provide a thermal balance for the body's frequently changing thermal conditions during intensive activities. The constantly changing intensity of the body's activities leads to a constant charging and recharging of the PCM-microcapsules. Applications for interiors are considered, however, they are in need of more research in order to successfully adapt this active thermal regulation technology to much slower charging and recharging rhythms of the PCM. The companies Outlast and Schoeller are the specialists in this research and in use of PCM technology and are keen to overcome this problem, thus opening up a vast new market.

This technology has been employed in my textile experiments by incorporating PCM coated nonwovens, manufactured by the company Outlast (see Fig. 185).

10.7 CONDUCTIVE MATERIALS

'Conductive fabrics combine the latest finishes with high metallic content in textiles that still retain the comfort required for clothing.[30] In fabrics these materials are integrated mainly in a form of yarns due to their flexibility. Textile fibres such as silk or polyamide are being coated with nickel, copper and silver of varying thickness or yarns are being made of pure stainless steel filaments. These yarns can be woven, knitted or sewn. However, several types of coating solutions after fabric formation are also possible. This allows an extensive range of combinations of physical and electrical properties, with plenty of applications for new design solutions. Another type of material included in this group is carbon, which is conductive too. Such conductive materials are available with a relatively low resistance and have been developed as an alternative to using traditional insulated copper wire. The main applications for conductive materials are electromagnetic interface (EMI) shielding and conducting, according to their specific properties.

There are also other applications for conductive textiles such as heated clothes for extreme winter conditions or heated blankets. For these applications conductive materials with high resistance have to be used and '[i]n these cases a heat or energy source is needed as the conductive material is not able to generate its own energy, it is only capable of conduction, to distribute the heat throughout the entire fabric or garment.'[31]

It is important to recognize that these two types of materials have been developed with different purposes in mind. The conductive inks and yarns transmit electricity with only a small amount of the electrical energy converted to heat whilst the resistive materials conduct electricity with a large amount of the electrical energy converted into heat. To sum up, conductive materials are used to move electrical energy from point A to point B, retaining the maximum amount of energy to do work at point B; whilst resistive materials are used to move electrical energy from point A to point B, considerably warming up the pathway between the two points and leaving very little energy available to do work at point B.

In my textile experiments, Carbon 7102 Conductor Paste with high resistance supplied by DuPont, and BEKINOX® VN Tex 500 100% stainless steel filament yarn from Bekintex with average linear resistance (R) 14 Ω / m are used.

Pure silver ink ELECTRODAG® 725A (6S-61) from Ancheson, a National Starch & Chemical Company was used to coat textile and other surfaces to obtain anti-bacterial finishes and to provide electomagnetic shielding properties to the fabric. As discussed earlier (Chapter 07.3) silver is well known for its anti-bacterial and EMI shielding properties. Additionally, silver, having the highest electrical conductivity, has anti-static properties and integrated into textiles it helps to avoid unpleasant electrostatic discharges.

For the above mentioned reasons, commercially available silver-coated fabric Padycare® from Tex-A-Med GmbH was also used bonded together with other textiles to create composite materials (see Fig. 192).

10.8 STIFFENING MATERIALS

Several stiffening techniques have been introduced into my work in order to achieve the functional and aesthetic qualities required. In a range of experiments latex and silicone coatings were introduced because of the material's skin-like optical and tactile qualities. A silicone rubber compound ELASTOSIL® RT 601 by Wacker Silicone, provided by Honeywill & Stein Ltd was found to be particularly useful for making transparent three-dimensional moulded pieces by casting. ELASTOSIL® RT 601 can be coloured easily using typical screen printing pigments, has excellent tensile strength and medium cured hardness after vulcanization. At a later stage, latex and clear polyester casting resin from Vosschemie GmbH were used to produce solid moulded panels with embedded textile structures.

For purposes of temporary stiffening of silk fabrics made of S-warp and Z-weft in order to obtain specific three-dimensional surface patterns a solution made of water and sugar (8:2) was used. MANUTEX and water mixes were also found to be useful (also known as digital print paste: urea - 100g, hot water - 300g, MANUTEX - 600g, sodium carbonate - 30g). If permanent stiffness had to be achieved, photo emulsion BLACK MAGIC VARIO was used.

10.9 OTHER MATERIALS

Polyolefin foam sheets under the tradename ALVEOLIT® from Alveo AG were used for the experiments. The material has excellent thermal insulation, high elasticity, is non-toxic and environmentally-friendly. Additionally, household foils and baking papers were also employed.

10.10 SURFACE DESIGN TECHNIQUES

During the development of new mixed-media textiles various printing, dyeing and other surface design techniques were employed.

10.10.1 DYEING

Most of the fabrics used were white in their natural state, therefore the introduction of colour was necessary. This was done using a wet dyeing method and the so-called dry dyeing method – heat transfer printing.

10.10.1.1 WET DYEING METHOD

The wet dyeing process was applied to Colback® nonwovens which are made from biocomponent filaments with a polyester core and polyamide skin. Sirius direct dyes provided by Bayer were used.

10.10.1.2 DRY DYEING METHOD

Heat transfer printing is the transference of an image, or simply a colour, to fabric via a substrate (usually transfer paper). Dyes are transferred to fabric via heat and pressure. For this purpose a special heat transfer press was used. Disperse inks work with most synthetic fabric, therefore the use of this technique was possible on polyester type fabrics. Deka transfer inks were applied provided by Deka Textilfarben GmbH. Typically the temperature was set at 190°C for 40 sec.

10.10.2 SCREEN PRINTING

Different screen printing techniques were employed in order to manipulate the appearance of the textiles as described below. For all of them print screens were prepared with the desired images. Sometimes an empty screen was used in order to print an uni-colour base.

10.10.2.1 PIGMENT PRINTING

Pigment printing using different pigment and binder systems was used. This includes the use of light and heat sensitive inks such as photoluminescent COLORMATCH PH 451 pigments (see Fig. 203) by CHT Beitlich GmbH (Chapter 10.4.1) and CHROMICOLOR AQ inks from the company Matsui (Chapter 10.4.2.2). The ordinary system of mixing pigment concentrate with binder emulsion Magnaprint Binder FF was also applied. Furthermore fluorescent pigments COLORMATCH FL were used (see Fig. 194) as well as PRINTPERFEKT paste both from CHT R. Beitlich HmbH. Puff pigments which expand when heated were used to create puckered three-dimensional effects on fabrics. The puff pigment PRINTPERFEKT EXTS-2 was supplied by CHT R. Beitlich GmbH and applied in combination with an ordinary water-based binder such as Magnaprint Binder FF and pigments (see Fig. 199, 200, 216, 217).

10.10.2.2 DISCHARGE

A discharge technique enables the creation of a negative printing pattern on a dark base cloth by introducing reducing agents which destroy the background colour. The negative images can be white or coloured if using illuminating dyes (see Fig. 198, 201, 202, 214, 215).

10.10.3 SURFACE EFFECTS WITH FOILS AND FLOCK TRANSFERS

Metallic foils to create a shiny appearance and TUBITRANS flock transfer systems to produce a matt three-dimensional flocked effect were used. Metallic foils were supplied by Leonhard Kurz and TUBITRANS flock transfer sheets by CHT Beitlich GmbH. Prior to applying these materials, the surface of the cloth was covered with adhesive net SPUNFAB® provided by Hänsel to create the desired pattern. Then metallic foil or TUBITRANS is placed onto the fabric surface and passed through the transfer press to bond both substances together (see Fig. 208, 209).

10.10.4 DIGITAL PRINTING

Experiments with digital printing using Mimaki technology available at the LCF, Textiles Research Unit were also conducted. The intention was to use the photographic representations of the skin obtained from the microscopic imaging sessions. For the same reasons experiments with Kyrell and Epson ink jet transfer foils were carried out (see also 10.2). These transfer films were ink-jet printed with digitally manipulated patterns of the skin's surface using an ordinary ink-jet printer. Then the image was transferred onto the fabric by ironing or passing through the transfer press. In this latter process limitations in size must be considered, as only a maximum of A3 size films can be prepared (see Fig. 204, 205).

10.10.5 BLACK AND WHITE PHOTOGRAPHIC IMAGES

Black and white photographic images of the skin's surface were developed onto cloth using the same technology as for photographic prints on photo paper. Photo emulsion BLACK MAGIC VARIO and photo gelatine BLACK MAGIC were used for these experiments to equip fabric with the necessary properties of a photo paper. Then black and white skin images were projected on the cloth and photographic representation obtained (see Fig. 206, 207).

10.10.6 BAKING

Experiments involving baking certain materials in an oven were carried out in order to change the material's surface structure by shrinking them at a high temperature. The temperature and timing were varied (180°C – 220°C, 0.5-4 minutes) according to the desired degree of shrinkage and type of the material used (see Fig. 191).

10.10.7 THERMOPLASTIC MOULDING

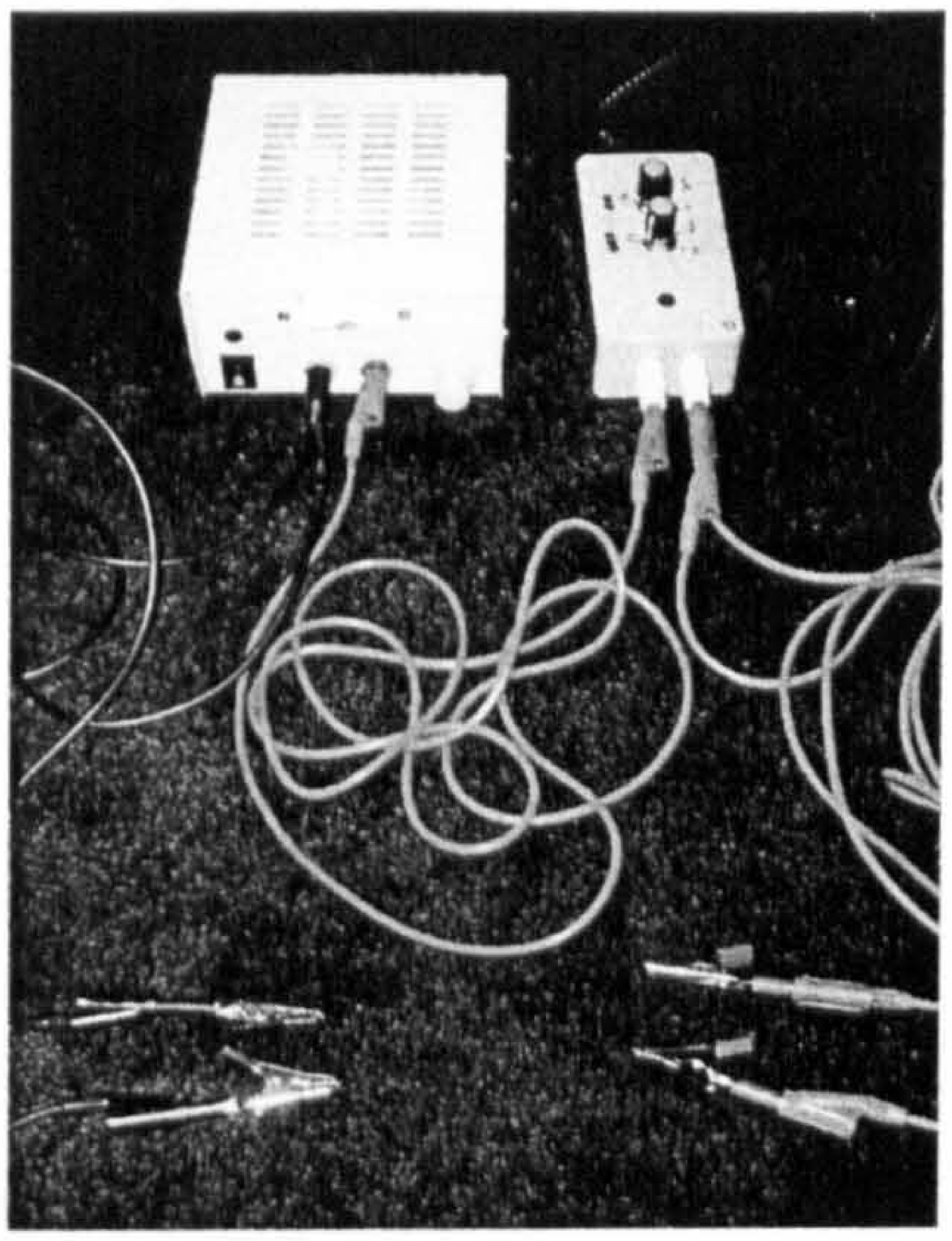
Some fabrics which have good thermo-plastic properties such as polyesters or polyamides were moulded to create three-dimensional shapes using the transfer press. Typically the temperature was set at 190°C for 1 minute (see Fig. 225, 226).

10.11 ELECTRONICS AND ELECTRICAL DEVICES

In order to accommodate my experiments, two laboratory DC power supplies were used; one with a maximum output of 15 V, 1,5 A and another with a maximum output of 30 V, 3 A. For simple tests a 9 V Duracel® battery with electric cords attached was used. Electric heaters and a hair dryer were also employed in some cases to influence the colorchange process.

Specially engineered electronics prepared by Colin Dawson, my external advisor, were used for the final prototypes described in Chapter 12:

- a remote controlled ultra red box which opens and closes an electric circuit to accommodate the electrically stimulated colourchange process
- specially modified timers to control electronics.



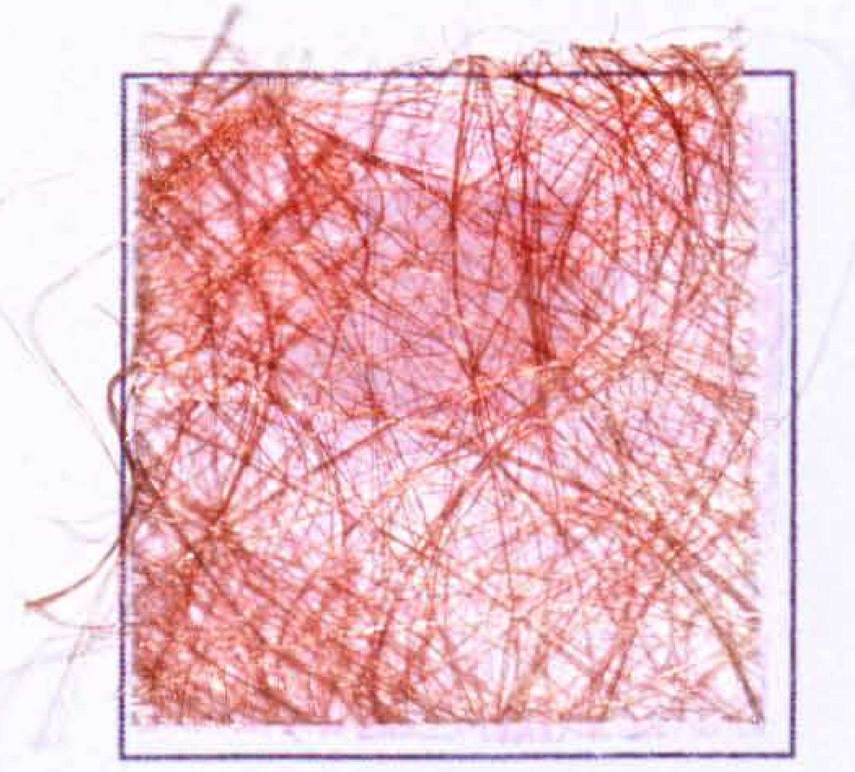
152 Working kit:

1) a DC power supply with a maximum output of 15 v, 1.5 A (left);

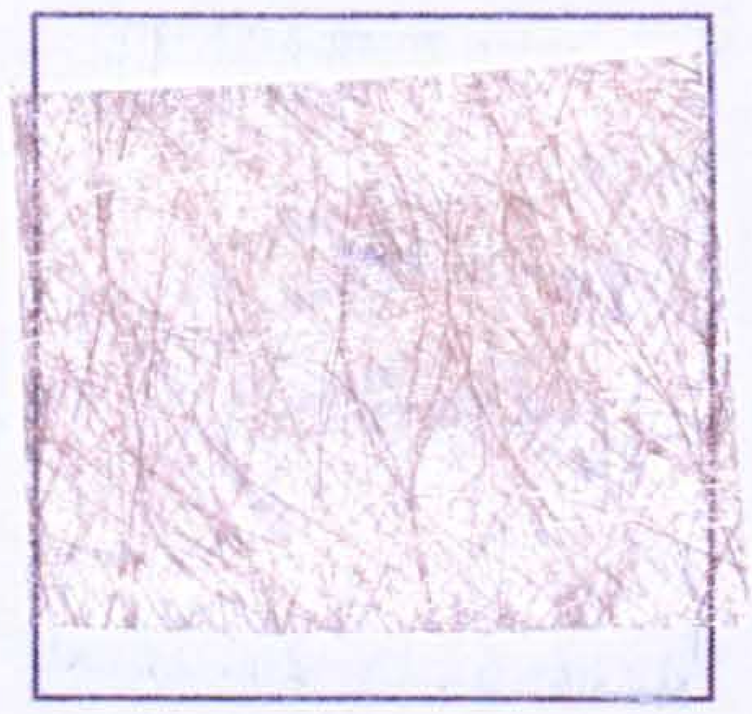
2) a specially modified timer to control electronics (right);

3) wires leading to the positive and negative terminals of a power supply.

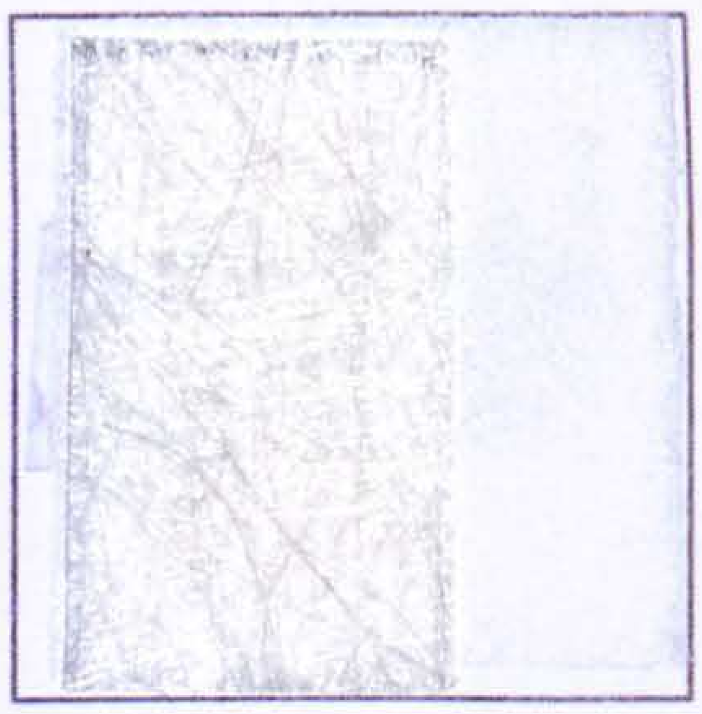
152



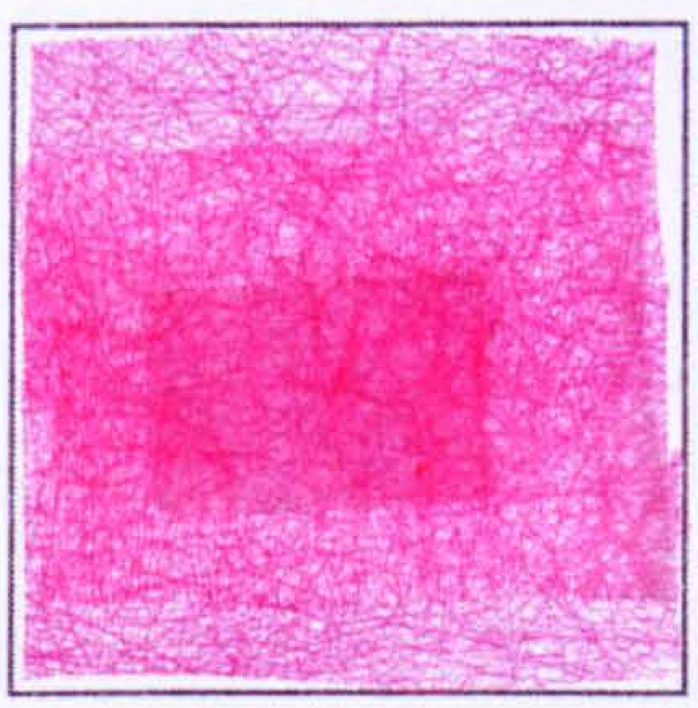
Coldback® WF30



Coldback® WF50

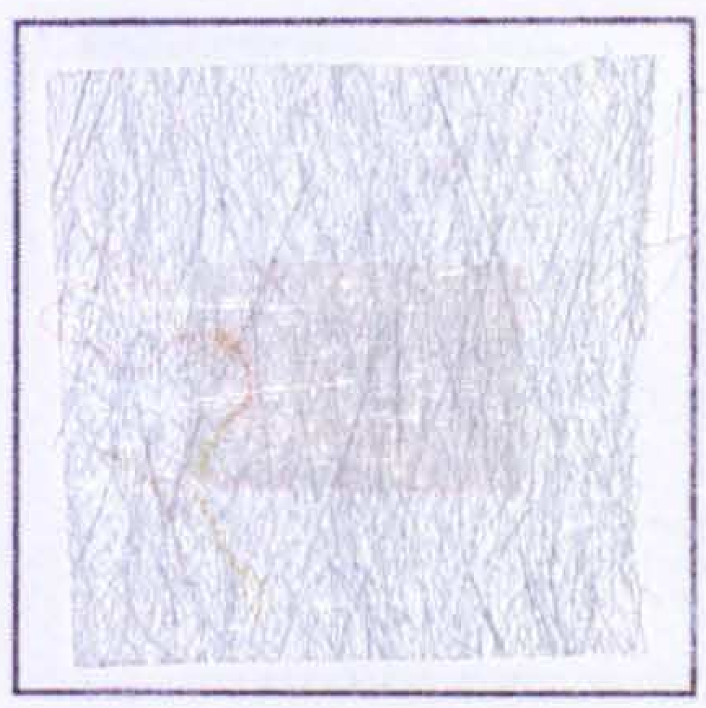


Coldback® WF120

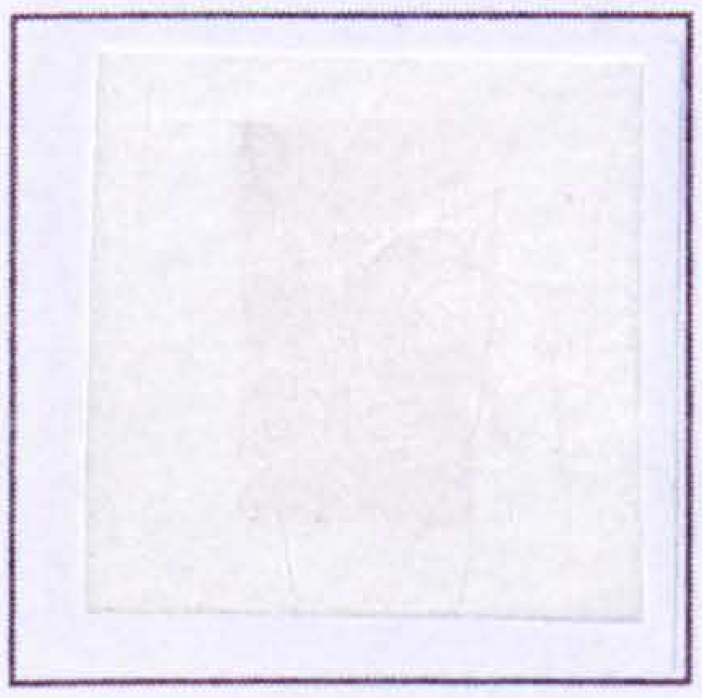


PINK VIBRAtex®, type B4

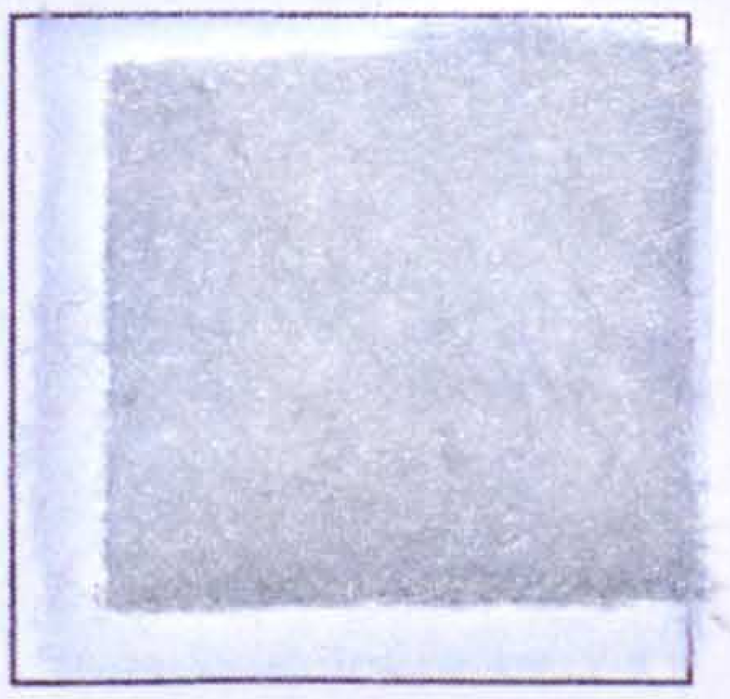
ORION® TM, type DU 025



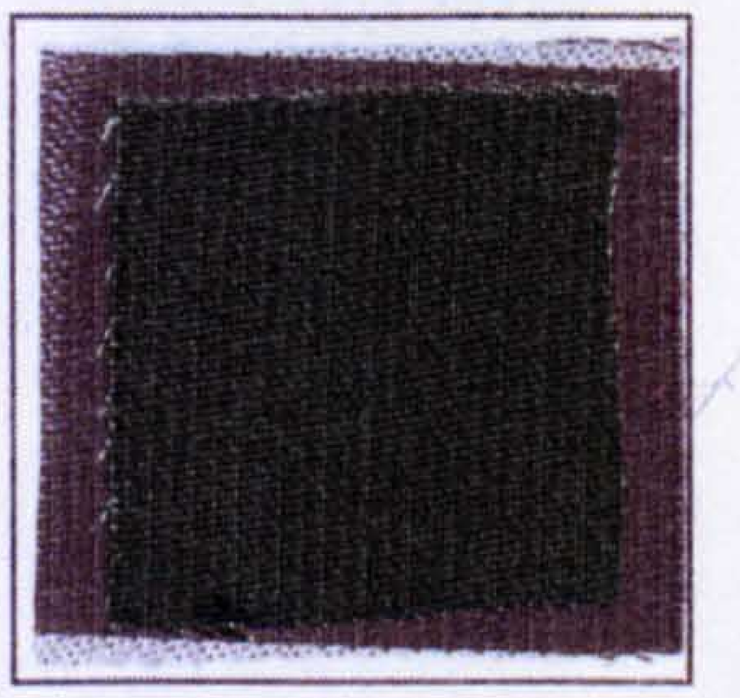
Polyester spunlaid nonwoven



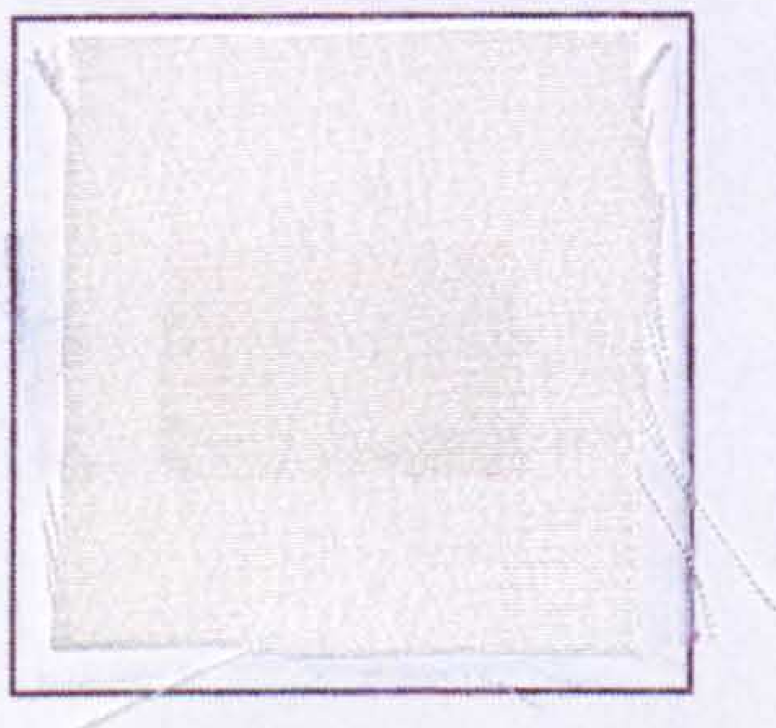
DROP SCREEN PAPER®



Polyester fleece

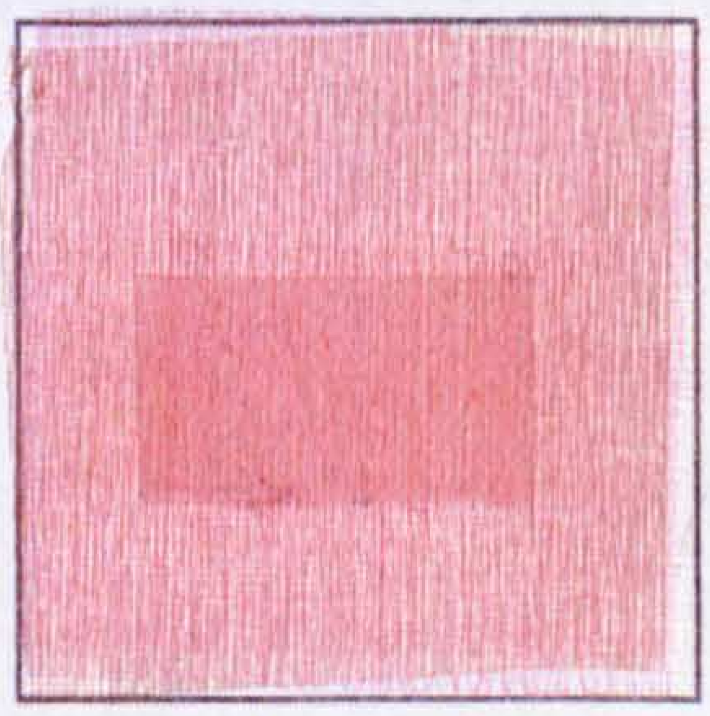


Woven 100% cotton

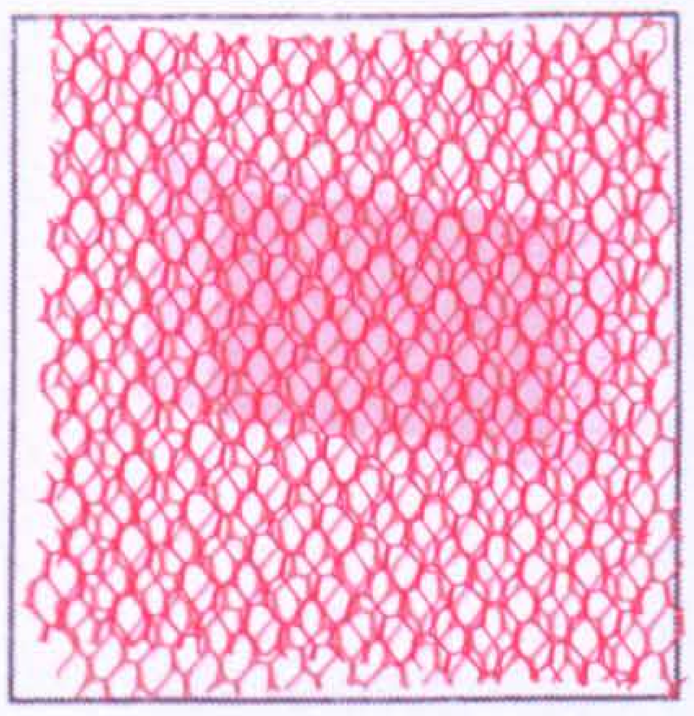


Silk

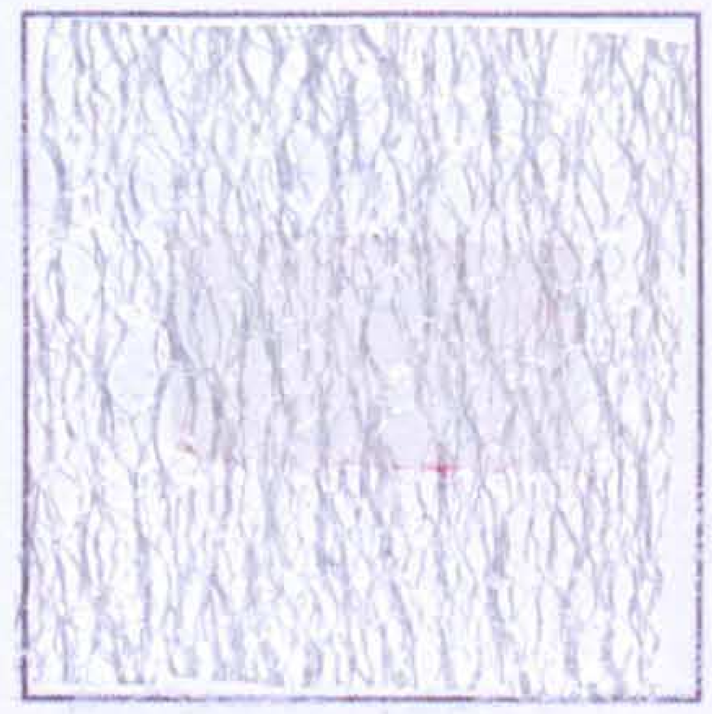
Crepe silk



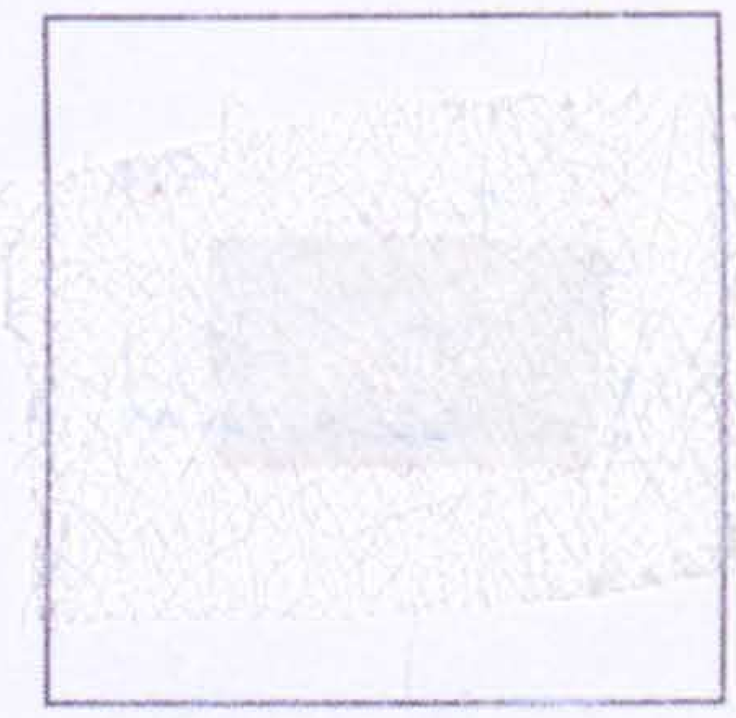
Nylon



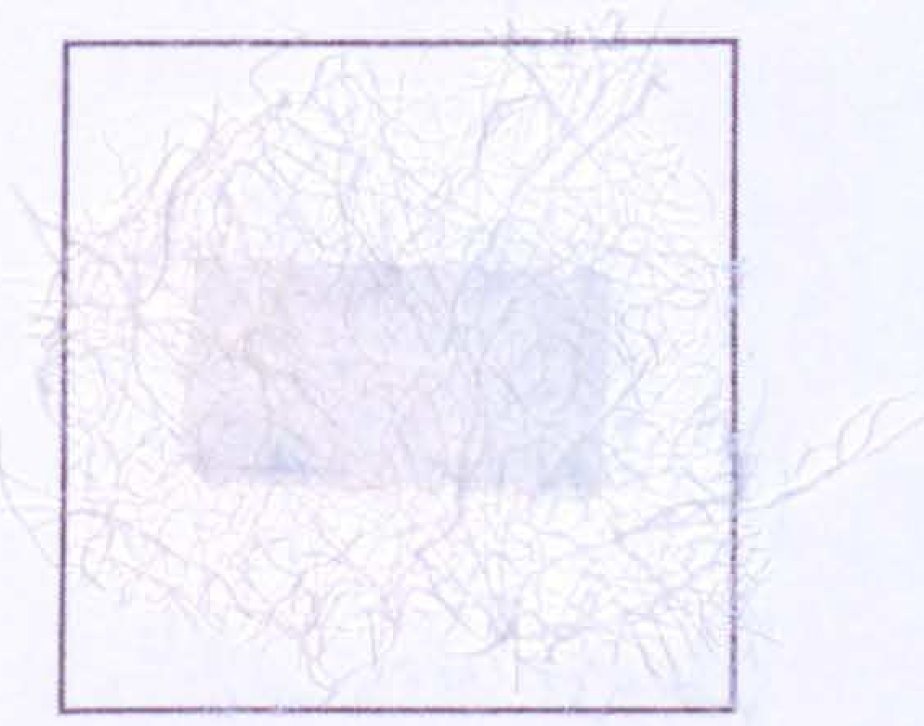
Tulle



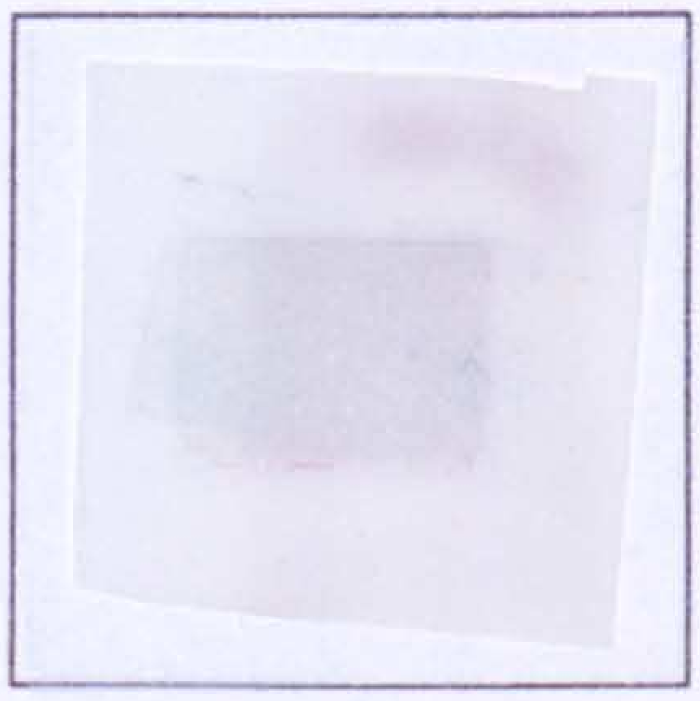
SPUNFAB® ABA 001



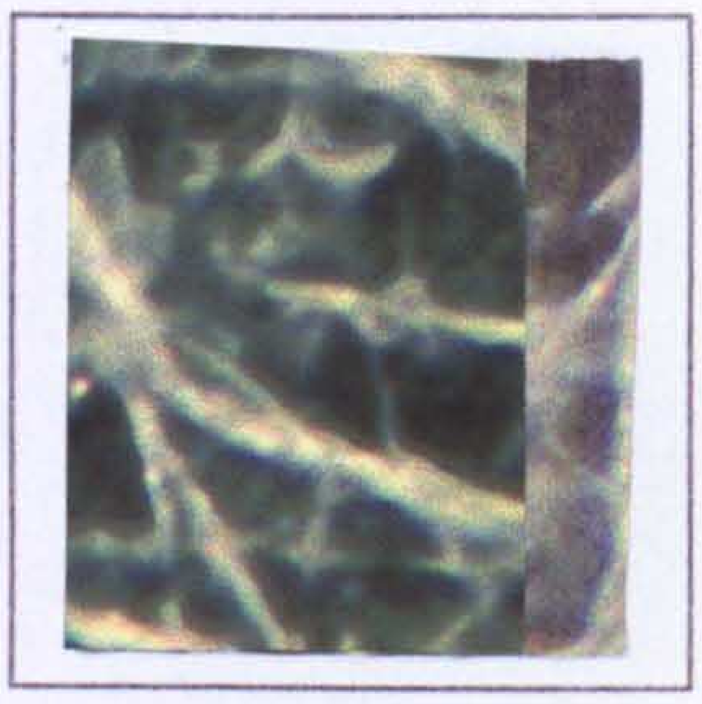
SPUNFAB® PE 2900



SPUNFAB® SL 7001



Thermo-adhesive film IR type T2



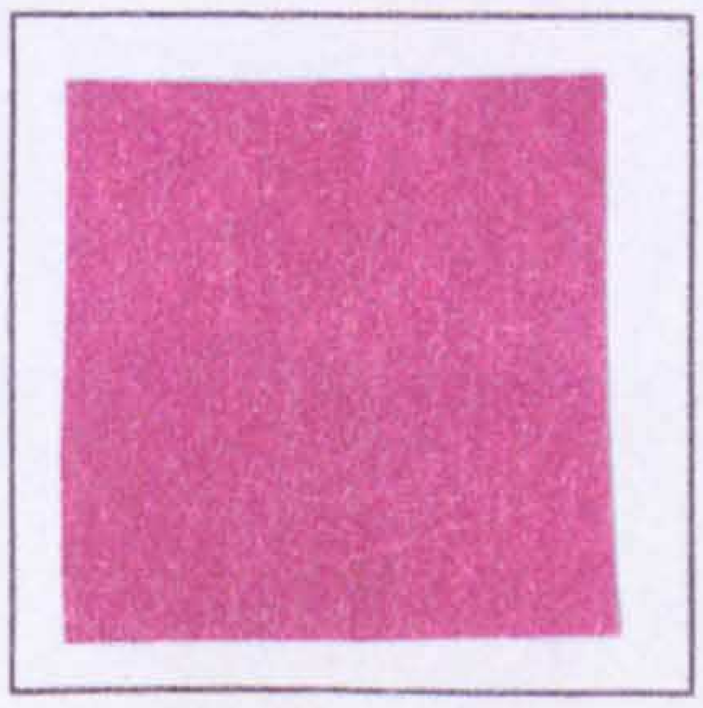
Epson ink jet transfer foil

Phosphorescent printing ink COLORMATCH PH 451 on fabric

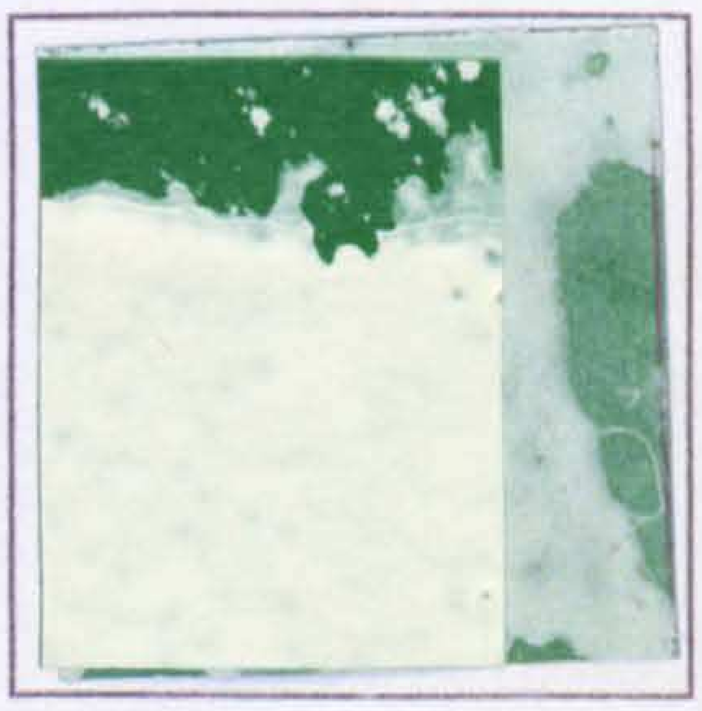
Thermochromic Liquid Crystal C22-27 series printing ink on paper

Thermochromic Liquid Crystals coated on a polyester sheet, C22-27 series ink

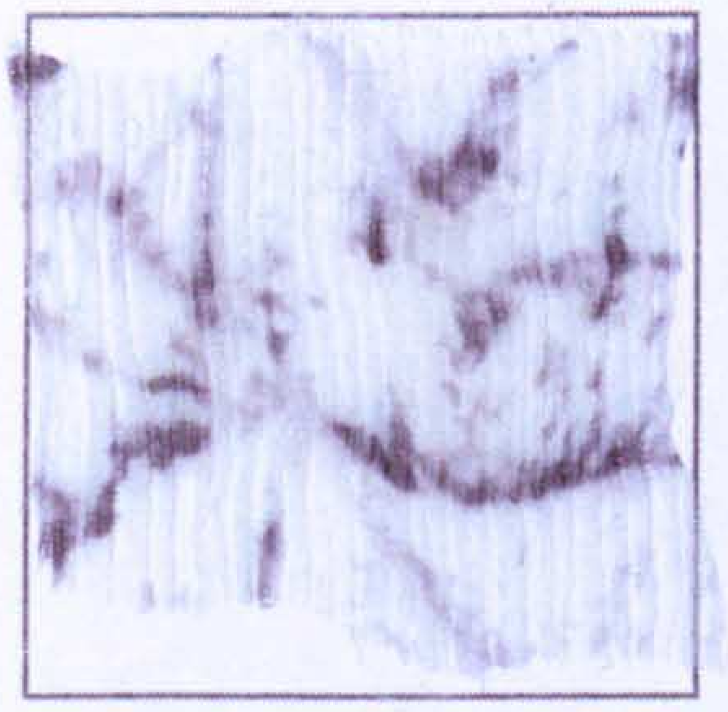
Thermochromic CHROMICOLOR AQ ink (hand-touch formulated) printed on DROP SCREEN PAPER®



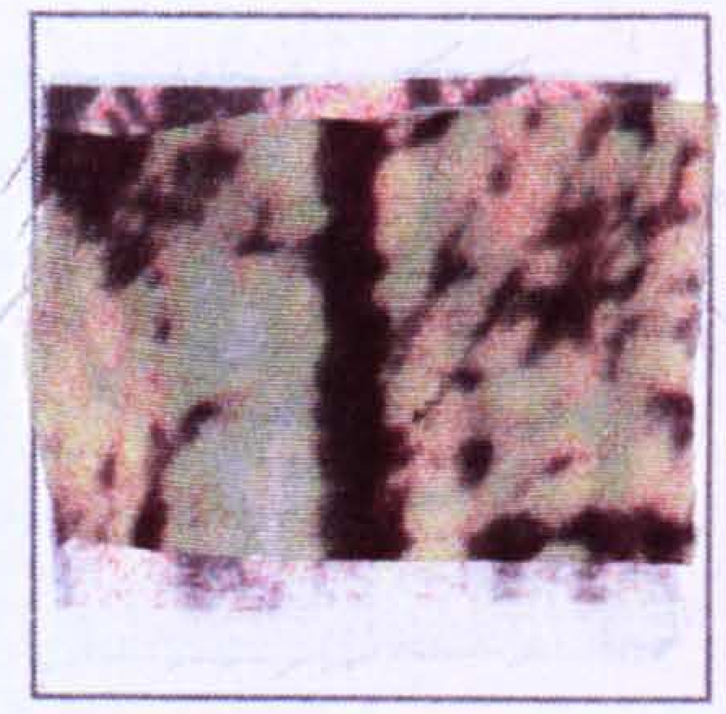
AROMA®, Ambrosia



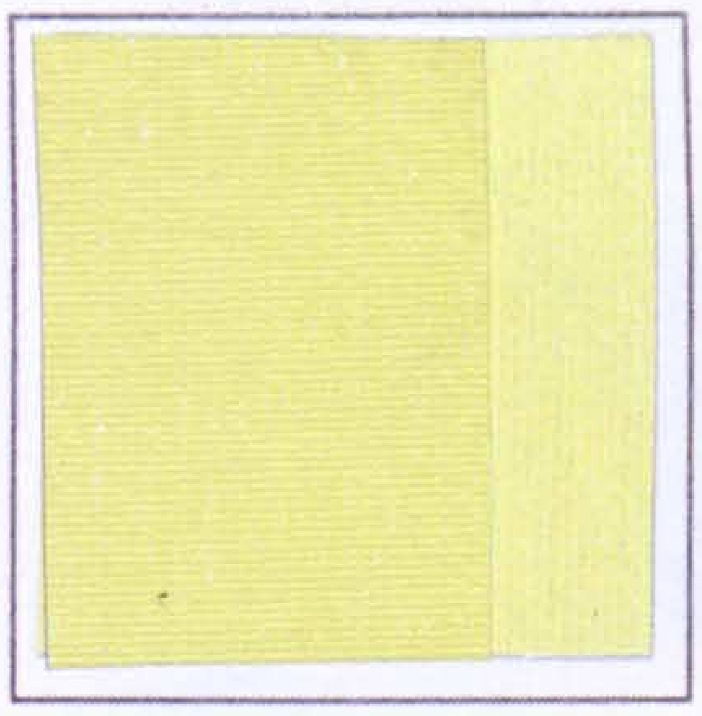
Encapsulated lemon oil



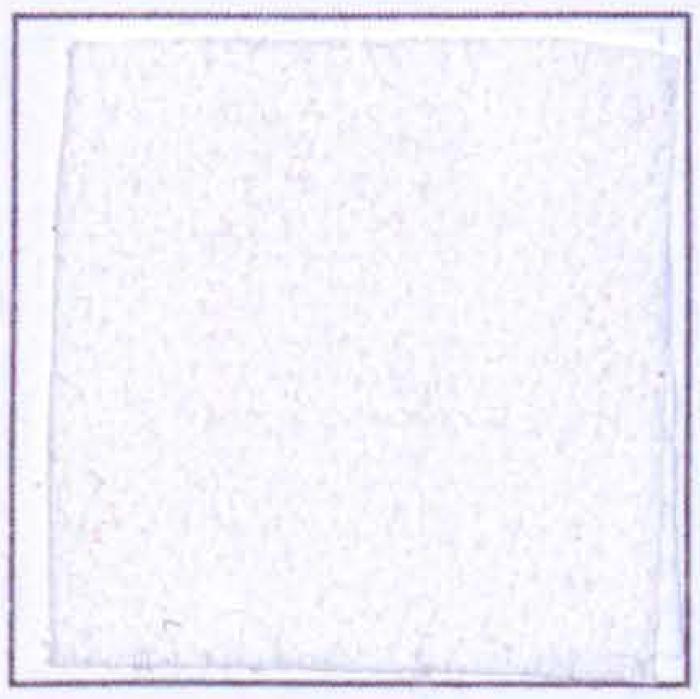
BREEZE® finish



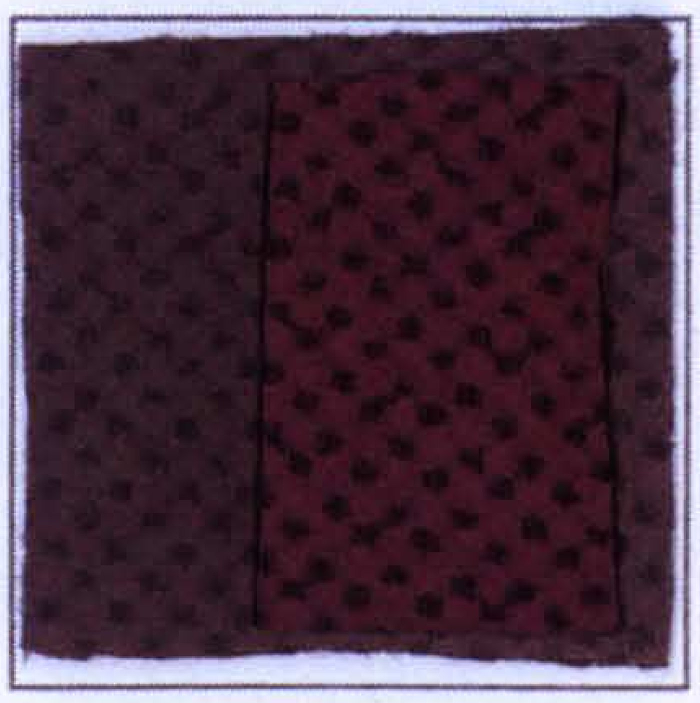
BaKaSave® coated fabric



Industrially coated BaKaSave® fabric

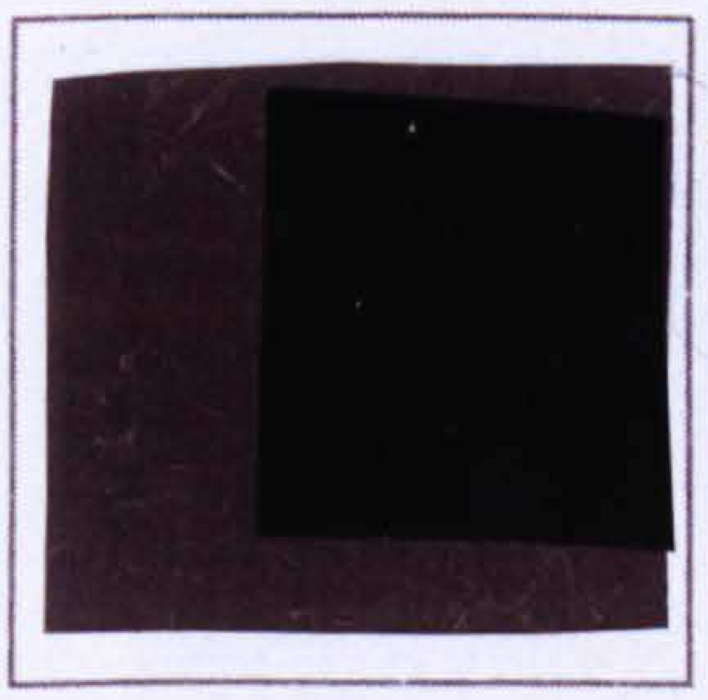


PCM, Outlast®

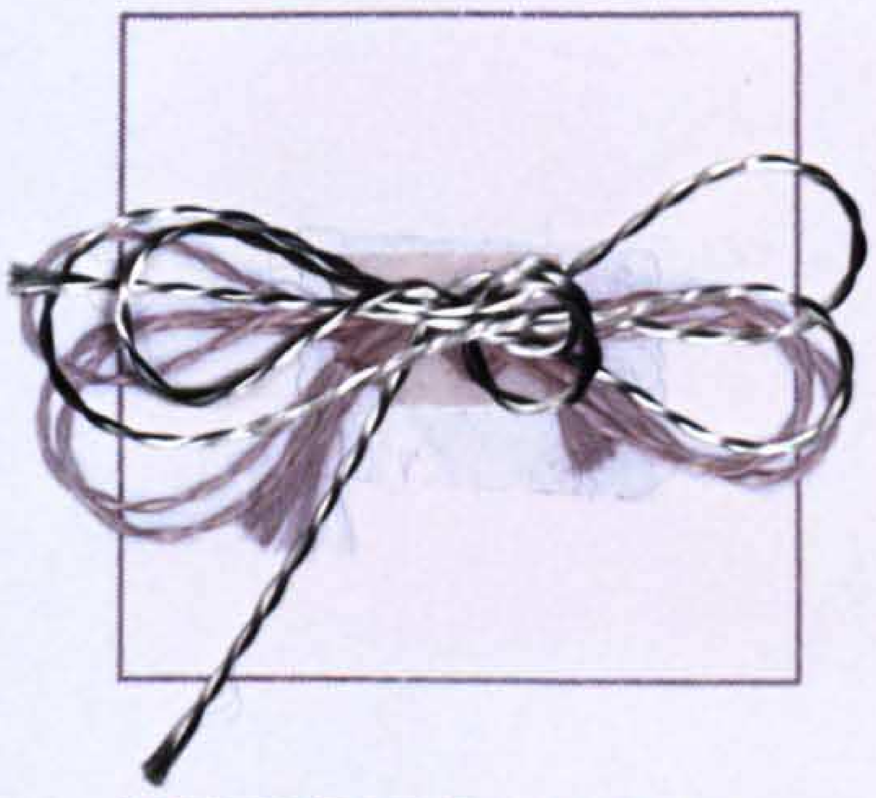


PCM, Outlast®

PCM, Outlast®

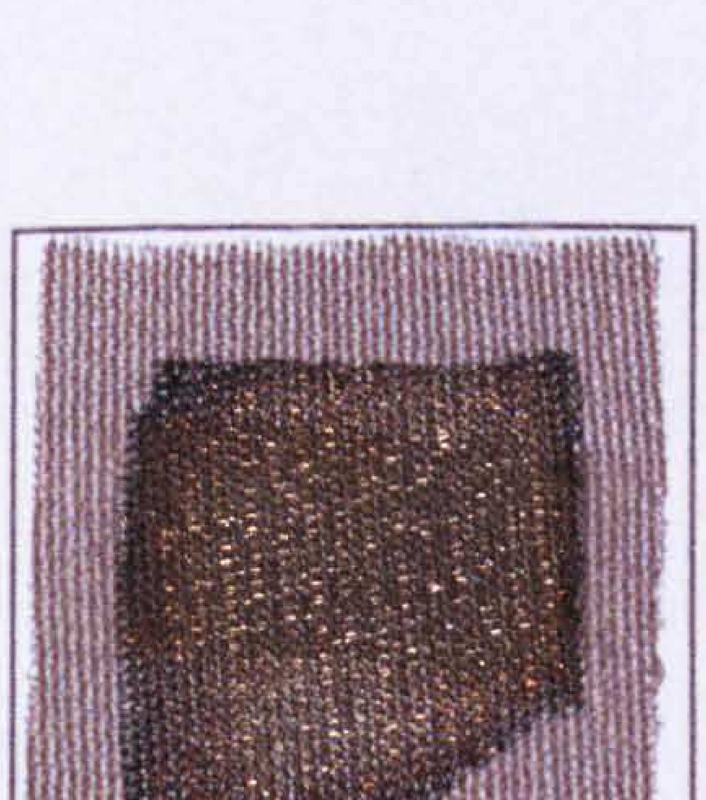


Carbon 7102 Conductor Paste

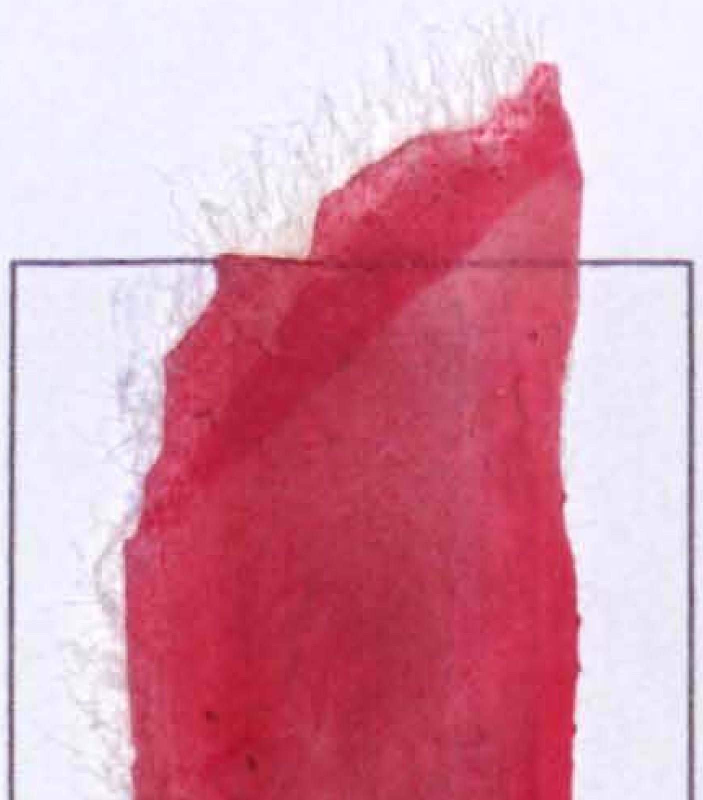


BEKINOX® VN Tex 500 100% stainless steal filament yarn

ELECTRODAG® 725A (6S-61) silver ink



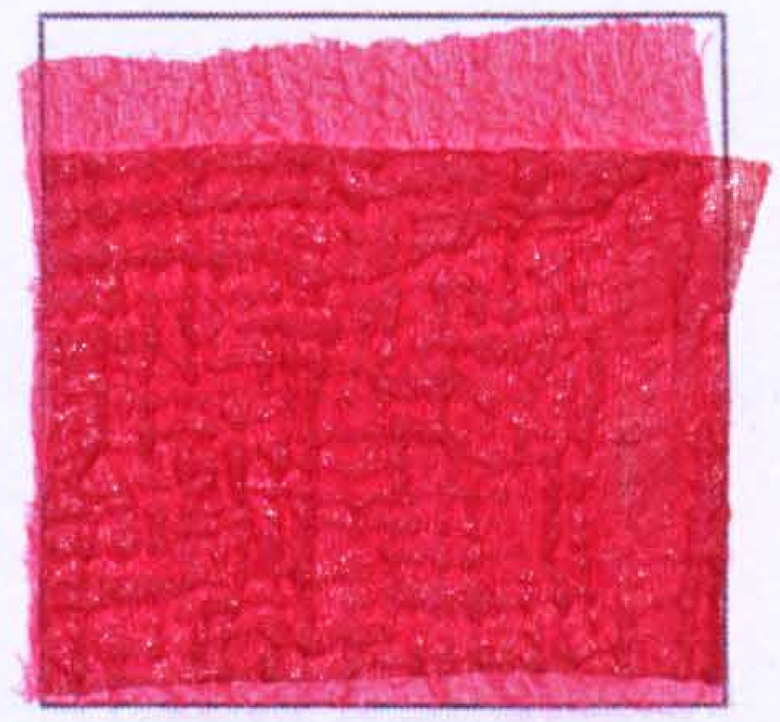
Padyca[illegible], siver coated fabric



Silicone ELASTOSIL® RT 601 on ORION® nonwoven

Latex on paper

Solution made of water and sugar (8:2) on silk crepe



MANUTEX solution on crepe sil

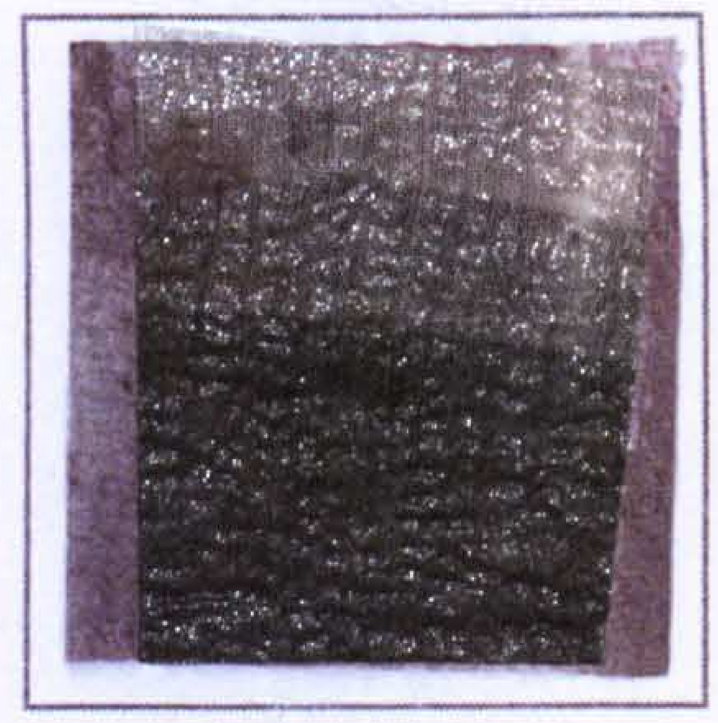
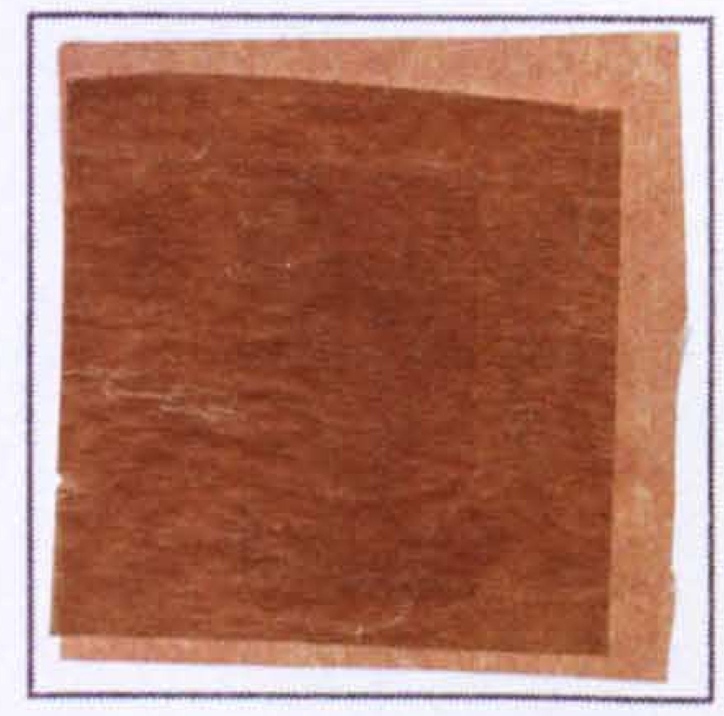


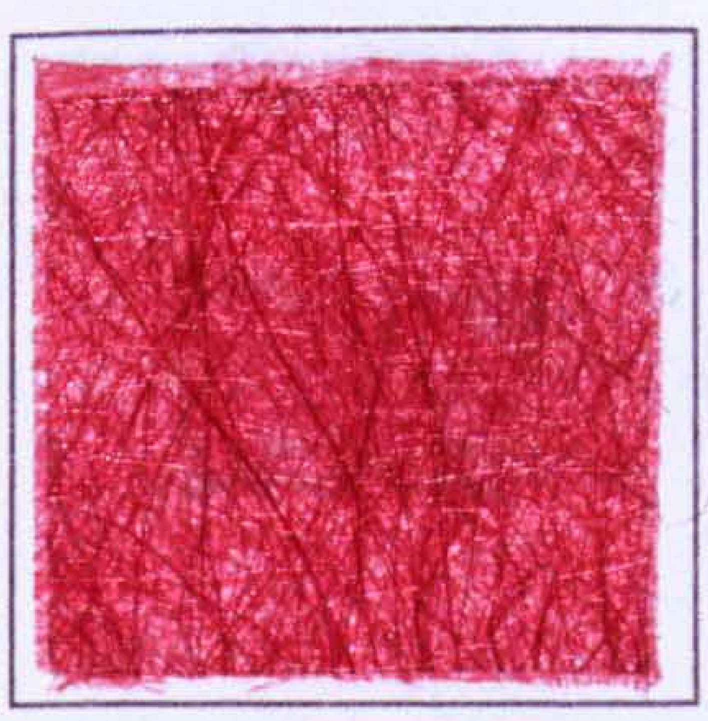
Photo emulsion BLACK MAGIC VARIO on silk crepe

AVEOLIT®

Household foil

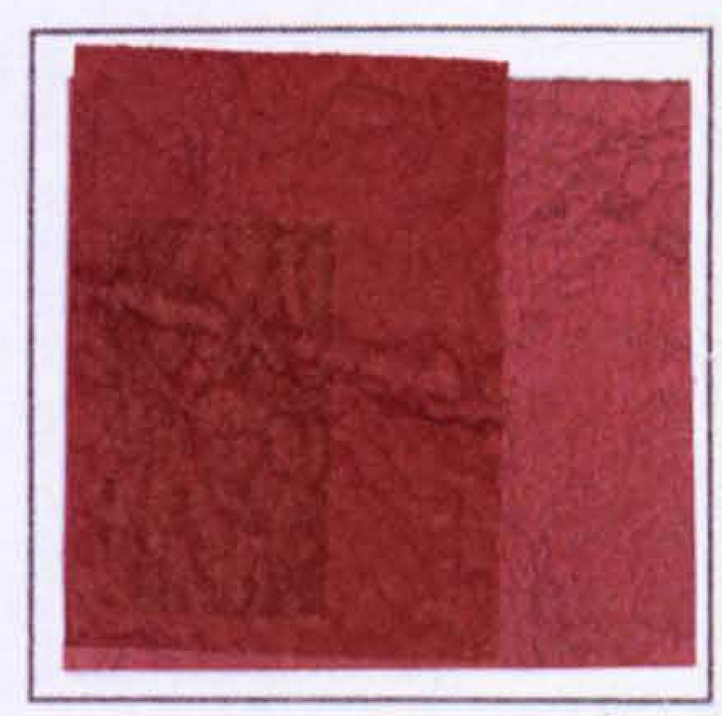


Baking paper

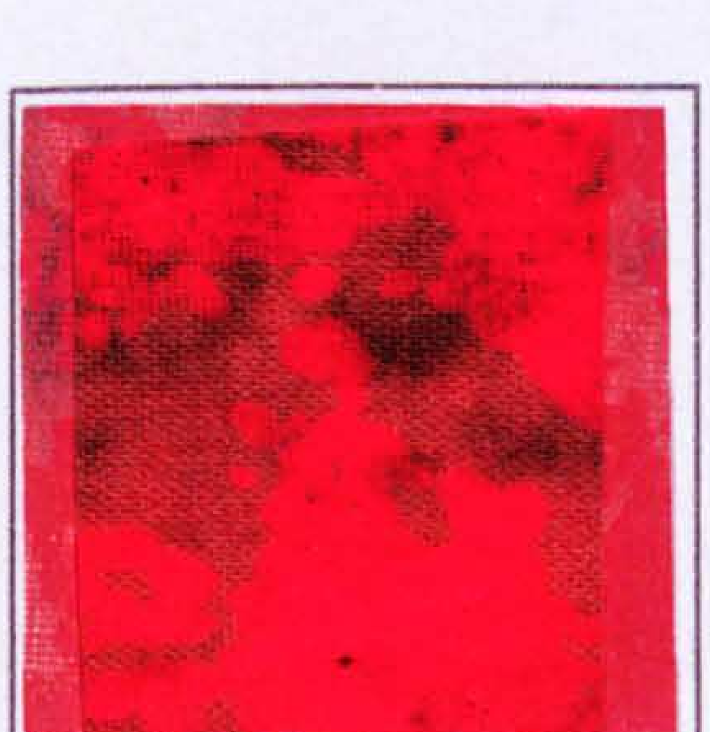


Dyed Colback® nonwoven, Sirius® dyes

Heat transfer printing on polyester nonwoven, Deka transfer inks



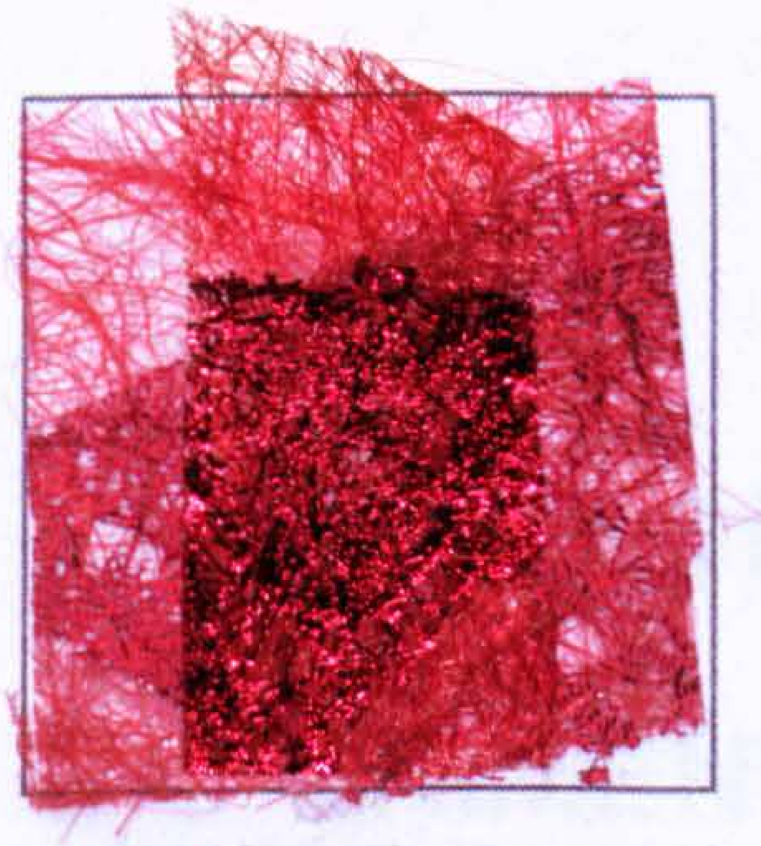
Deka transfer ink on transfer paper



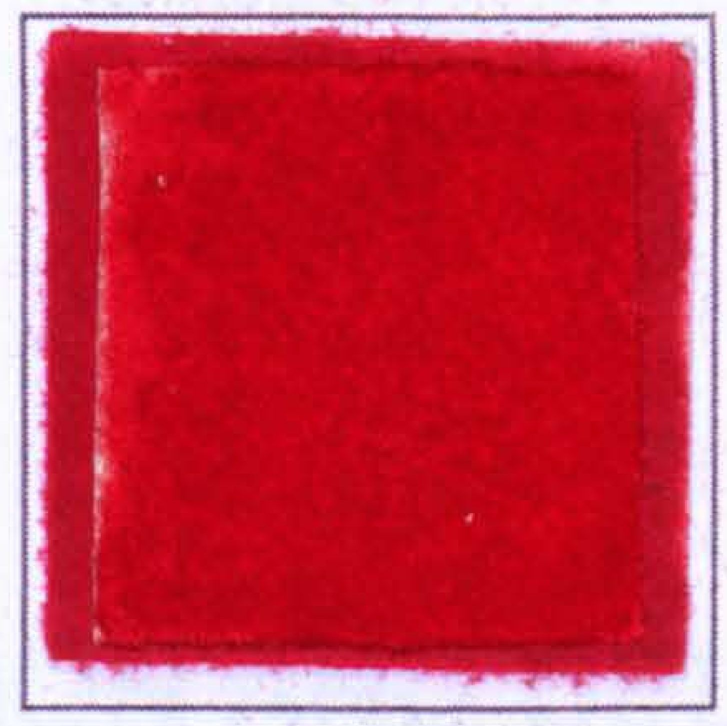
COLORMATCH FL

PRINTPERFEKT EXTS-2

Discharge print on fabric



Metallic foil applied on fabric



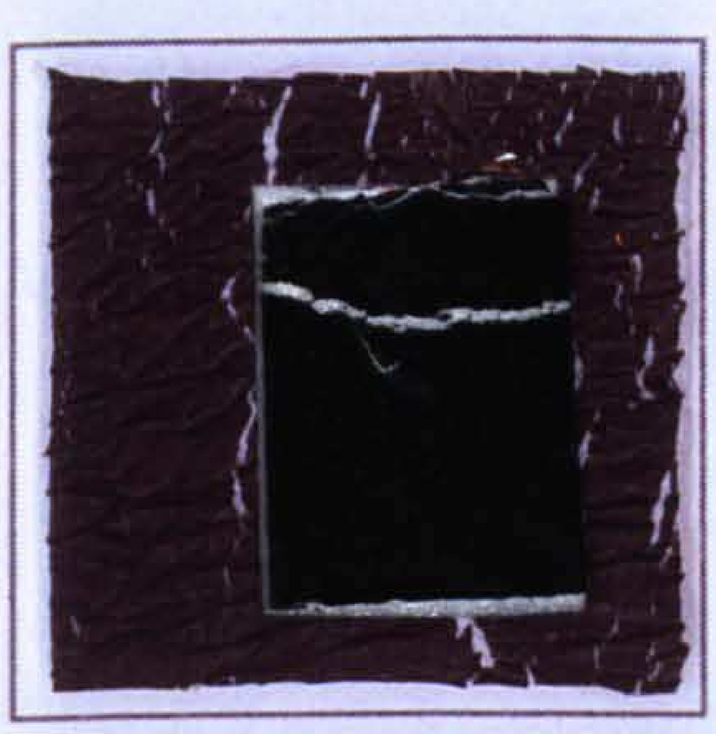
TUBITRANS flock transfer

Digital print on fabric, Mimaki technology

Ink jet printed Epson ink jet foil applied onto fabric

Photographic image on cloth, fabric treated with BLACK MAGIC VARIO photo emulsion

ELECTRODAG® 725A (6S-61) on ALVEOLIT®, baking in an oven, 3 minutes, 190 °C



Carbon 7102 Conductor Paste on ALVEOLIT®, baking in an oven, 2 minutes, 210 °C

3-D moulded polyester nonwoven, transfer press and transfer inks

CHAPTER 11 ::

EXPERIMENTATION AND DELIVERABLES

11 EXPERIMENTATION AND DELIVERABLES

In order to meet the stated aims (Chapter 01) of the research, a series of practical experiments were carried out using materials and technologies previously described in Chapter 10 following the designing principles as featured in Chapter 09. During the empirical and technical stages of the experiments my attention was focused on the selected aspects of skin 'technology', referred to as sensor and biochemical mechanism, which react to physical and psychological stimuli. This route led me to investigate the interactive and decorative potential of thermochromic and touch-sensitive surfaces by relating them to the transient skin images and patterns that exist due to the functions of our nervous system and blood circulation as discussed in *Skin Biology* (Chapter 04). I also examined the thermochromic properties of textiles as indicators of fluctuating conditions in the interior.

Other aspects of my practice led research SKIN STORIES :: CHARTING AND MAPPING THE SKIN are informed by the skin analogy as a thermo-regulating and immunological surveillance and biochemical mechanism, as identified during my theoretical enquiry. These aspects induced me to explore the potential of textiles as latent heating systems to control room temperature and to address the olfactory and filtering potential of textiles as deodorising, anti-microbial and curative surfaces. This resulted in a series of experiments testing appropriate materials and technologies contributing to the development of polysensual and interactive textile surfaces for the concept of 2^{nd} and 3^{rd} skin.

As a result of these experiments, three methods of production were developed to a prototype stage, namely the VERSICOLOUR system, the MULTICOLOUR CHROMIC DESIGN system and Heat 'n Sniff method, all with integrated electronics. These systems, which can be used separately or together, suggest new designing possibilities using thermochromatic inks, scents and ambient, electric or human heat. They can be additionally combined with other technologies, as shown later, to increase the responsive and interactive mode of the new textiles. Finally, the aspects of skin as a protector and a barrier were investigated and translated into a textiles vocabulary through a series of empirical and technical tests.

Throughout the process of practical case studies executed both in biological labs and in textiles studios, the aesthetics and multi-functional nature of skin, its structures and surface patterns were interpreted into new textile surfaces. It was particularly important for me as a designer to integrate electronics, industrial materials and smart technologies into fabrics in the most discrete ways possible, or to emphasise certain aesthetic qualities of these materials. The aim was to make such functional fabrics more appealing, desirable and user friendly by creatively combining technology with aesthetics. These experiments were based on my studies and personal perceptions of skin, combined with my knowledge as a textiles designer, and resulted in a wide range of innovative textile samples for body and interiors (see the following images and Textile File), a selection of these being brought forward to a prototype stage (Chapter 12).

11.1 COLOURCHANGE TEXTILES

Due to their chameleon-like nature chromatic materials are very appealing to designers in a wide range of areas, from product and graphic design to fashion and accessories. In product design these materials have been around for many decades. For instance, the mood rings and mood watches popular in the 60's and 70's changed colour in response to the 'mood' of the wearer (liquid crystal molecules change position according to changes in temperature and absorb or reflect certain wavelengths of light). Another novelty, the thermochromic Hypercolour T-shirt of the 80's, apparently failed because the colourchange garment lightened on the warmest places of the body, such as the arm pits, and was not considered particularly appealing. Currently there is a revival of chromatic materials within the context of high-tech and smart materials. The design solutions are becoming more complex and are featuring a more sophisticated approach to the use of this technology.

Within this new context, designer Elisabeth de Senneville was reported in 1999 to be one of the first to produce clothes for customers that change colour according to their body temperature, while her household range 'Senneville-Casa', launched in September 2000, features window blinds that turn grey when it rains and blue when the sun shines.'[1]

In October 2003 Materials Today reported: 'Maggie Orth from the Massachusetts Institute of Technology is currently producing one-of-a-kind, electro-textile wall panels. Instead of self-illuminating optical fibers, she is working with a fabric known as Electric Plaid ™ that exploits reflective colouring. The novel fabric contains interwoven stainless steel yarns, painted with thermochromic inks, which are connected to drive electronics. The flexible wall hangings can then be programmed to change color in response to heat from the conducting wires.'[2] (see Fig. 154, 155).

Based on Maggie Orth's research, International Fashion Machines (IFM) in Cambridge, Massachusets, together with Nike are negotiating the development of training shoes with textile panels that change colour according to how fast the wearer is running. Woven-in sensors could also record heart rate, hydration and blood sugar levels.[3]

There are more examples of the successful use of chromatic materials in diverse design concepts particularly in product design and some are featured in Chapter 05. Each of them demonstrates a different attitude towards the material and use of the technology. My design solutions, utilising the phenomena of thermochromy, are discussed below and form a central part of the interactive textiles concept SKIN STORIES :: CHARTING AND MAPPING THE SKIN.

11.1.1 PROGRESS ON COLOURCHANGE TEXTILES DEVELOPMENT

Two possible treatments for textile surfaces have been identified. They are both inks which can be applied onto fabric using screen printing techniques or by using a brush. One ink is a thermochromic liquid crystal ink (TLCI) (10.4.2.1) and the other is a thermochromic ink (TCI), which exhibits thermochromism through a molecular rearrangement structure (10.4.2.2).

Printed on dark, ideally on a black substrate TLCI can change colour from a red hue though the entire visible spectrum (red, yellow, green, blue, dark blue). The colour of the TLCI is determined by the background cloth temperature on which the ink is printed. TCI changes from the colour that has been determined at the time of manufacture (base colour) to transparent and back. TCI changes in a gradual way from the base colour through lighter shades of the base colour until full transparency is achieved. Both inks change colour in response to a change in temperature. The temperature at which a TCI starts to fade is termed the activation point and the temperature at which a TCI achieves full transparency is termed the threshold temperature. The activation point is determined by a manufacturer. TLCI can change colour within a temperature range previously set by a manufacturer, and the activation point is the temperature at which TLCI starts to change colour, going through the entire visible spectrum and returning to black above the set temperature range.

TCI costs approximately £300 per litre whilst TLCI costs approximately £1,000 per litre. An additional disadvantage of TLCI is that it is sensitive to UV light and cannot be exposed to direct sunlight for any length of time before the TLCI become 'fixed' and unable to change colour. However the far wider range of colour change that can be achieved with TLCI may outweigh the disadvantages of higher cost and UV sensitivity. Eventually, use of some UV stabilisers might be possible without destroying the extremely sensitive molecular system of TLCI. However, for the above mentioned reasons the use of TLCIs for my research experiments was strictly limited.

11.1.2 THE VERSICOLOUR SYSTEM

Given that both inks change colour in response to a change in temperature, I have decided to affect this temperature change by passing a low voltage (no greater than 24 V) of direct current (DC) through conductive materials that offer a high resistance to the passage of electricity. This resistance causes electrical energy to be converted to heat. This concept has been used to produce a wide range of products ranging from electric kettles to heated car seats, blankets and clothing.

I have chosen low voltage DC because it is much safer than using high voltage alternating current (AC) which is supplied by mains electricity. It is possible to convert mains AC into DC of the required voltage by using a transformer. There are many different types of transformers available on the open market at reasonable prices. In order to facilitate my experiments a power supply (with max. output 15 V, 1,5 A = 22,5 W) was used to control the colourchange process. In cases when very small areas printed with thermochromic inks were tested for the colourchange response, a simple 9 V Duracel® battery with electric cords attached was used.

Conductive inks, with a high resistance, that can be applied to a fabric by screen printing are also available commercially. The same applies to conductive yarns. I shall refer to such inks and threads as resistive materials. Such materials have been developed so that it is possible to heat a fabric, or a person wearing a garment made of such a fabric, using low voltage DC. Such conductive materials with a high resistance are incorporated into my textile designs together with thermochromic inks. Mainly two conductive materials with high resistance were employed in my experiments (see also 10.7):

a) Carbon 7102 Conductor Paste (DuPont)
b) BEKINOX® VN Tex 500 100% stainless steel filament yarn (Bekintex) with average linear resistance (R) 14 Ω / m that was sometimes doubled

The following formulas were used to measure the power of electric current essential for the temperature change process, which in turn is a key requirement for the colourchange process to take place within the new system:

$$P = V x I$$

where P is power measured in watts (W), V is voltage measured in volts (V) and I is current measured in amps (A)

or

$$P = R x I^2$$

where P is power measured in watts (W), R is resistance measured in ohms (Ω) and I is current measured in amps (A)

153 These formulas were used to measure the power of electricity.

My experiments have shown that it is possible to produce a colourchange fabric system, as seen in Figures 156 to 160, which consists of several distinct but closely interactive layers, that mimic skin architecture and behave like living skin. The layers are: a thermochromic coating, a textile substrate, a layer of conductive ink with high electrical resistance, and/or a layer with a conductive thread network resembling our nervous system. The wired textile is connected to a power supply and the entire system is activated by an electric current passing through it, causing the electronic fabric to warm up due to its resistance, which initiates a colourchange process (see Fig. 156 A - C).

Such a system, called the VERSICOLOUR system could be made using either TLCI or TCI and has been produced to yield a piece of fabric 15 square centimetres in size. Larger pieces of VERSICOLOUR fabric might be possible but this has not been attempted yet. Given that the resistive ink will warm up to a uniform temperature over its entire area after a certain voltage and amperage has been passed through it for a given length of time, the system will display a uniform colourchange according to the ink that has been heated. If it is a TLCI, then the system will display whatever colour the ink turns to at that temperature within the set temperature range. If it is a TCI, and the threshold temperature has been reached, then the ink will blanche and become transparent to reveal the colour of the base fabric onto which it is printed.

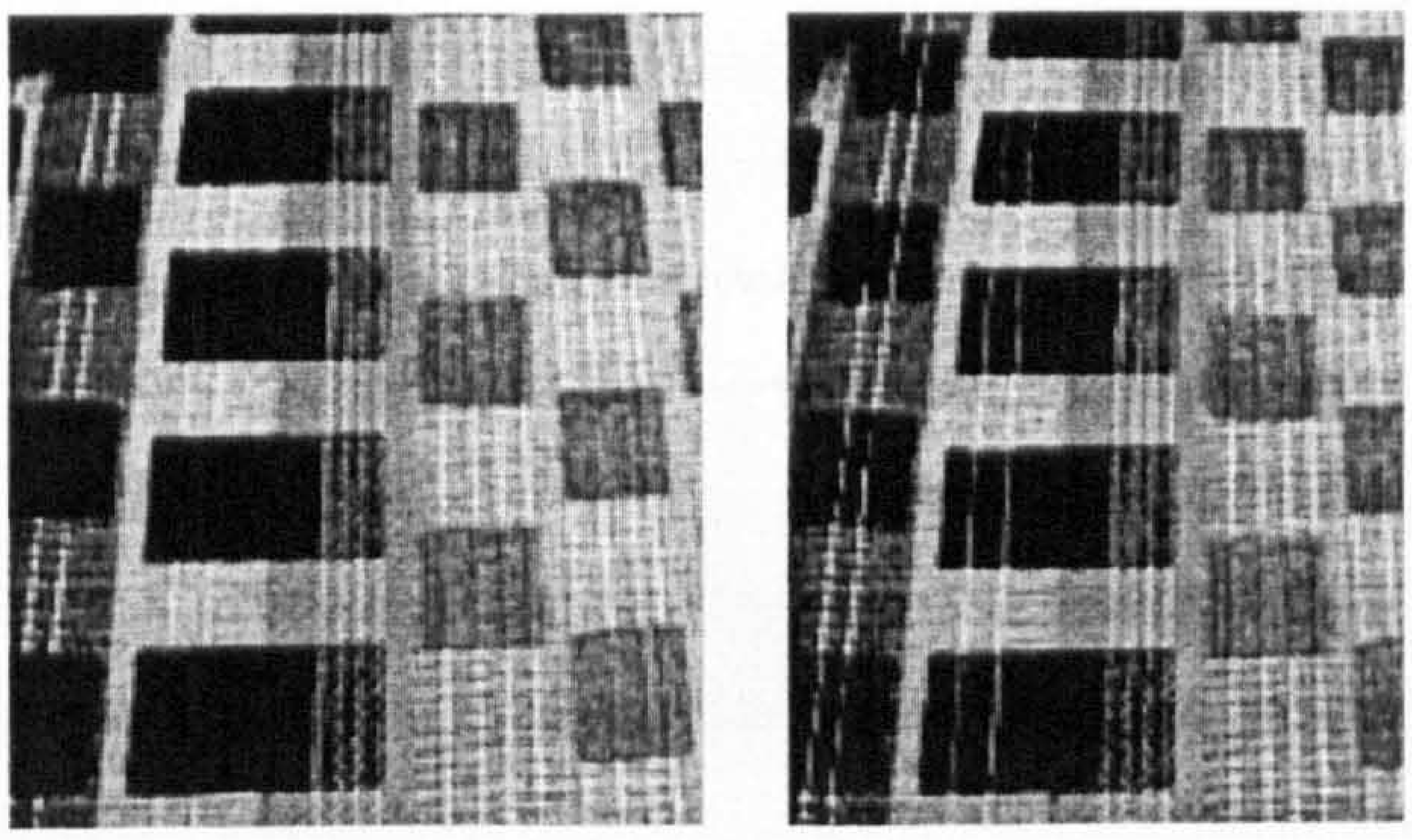
Figures 157 A and 157 B show another variation of the VERSICOLOUR system offering a variety of designing possibilities. Here a conductive thread or wire can be integrated (by bonding or embroidery) into a textile substrate, which is treated with thermochromic inks. Such thread with high linear resistivity naturally radiates heat when a certain voltage and amperage is being passed through it and creates the desired colourchange effect.

There are variations possible within the VERSICOLOUR system by changing the type of conductive materials used (ink or thread) and the way they are printed or arranged on the textile substrate (as stripes, as blocks, freely or as an overall block), provided that they do not cause a short circuit to occur. This allows a certain freedom in designing and controlling latent patterns that show up after the necessary amount of voltage and amperage has been applied. Figures 158 (A, B) and 159 (A, B) suggest some potential designing arrangements.

Whatever variation of the VERSICOLOUR system is used, it is always essential to know the end use of the textiles product designed: to what temperatures it might be exposed and whether it will be exposed to UV light (TLCI is UV light unstable). Since the colourchange activation point temperature is determined by the manufacturer, it is important to identify the most appropriate type of ink. My experiments have proved that TCIs with the activation point temperature at 24°C (threshold temp. 33°C) or 27°C (threshold temp. 36°C) were the most appropriate for the purposes of my design work. It is higher than normal room temperature but not too high, so that the colourchange process can be successfully stimulated using a low voltage.

For such a simple system, the only control that is required is an on/off switch, used to supply electricity for a given length of time. The VERSICOLOUR system can be made more sophisticated by including a thermocouple (an electrical thermometer of a very small size) to measure the temperature of the fabric and turn the power on or off accordingly, in order to maintain a constant temperature.

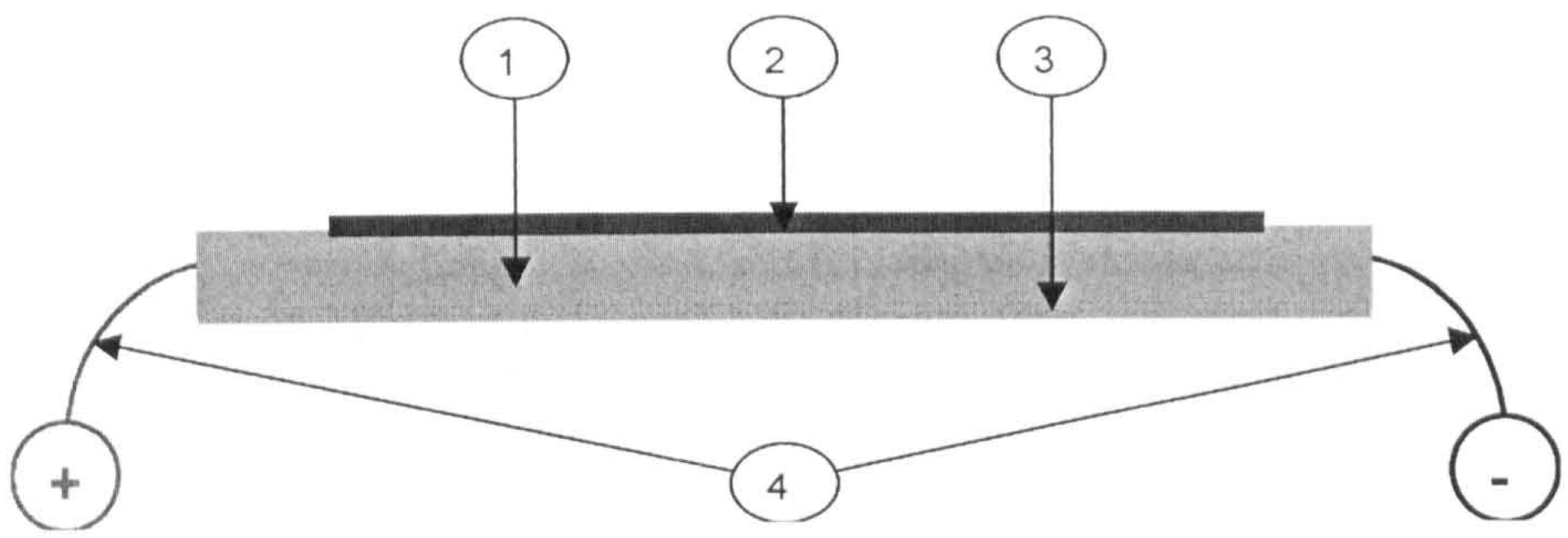
The VERSICOLOUR system has the potential to advance in many ways. The analogue control system used for this research could be updated to a digital control system for more refined displays. Such a system would be controlled by a computer programme which can send signals to conductive patches located on a X-Y matrix in order to switch on or off each patch independently (Fig. 160). This would allow one to have several 'layers' of texts, patterns or designs that can be activated when needed, and allows the changing of informative or visual input as required.



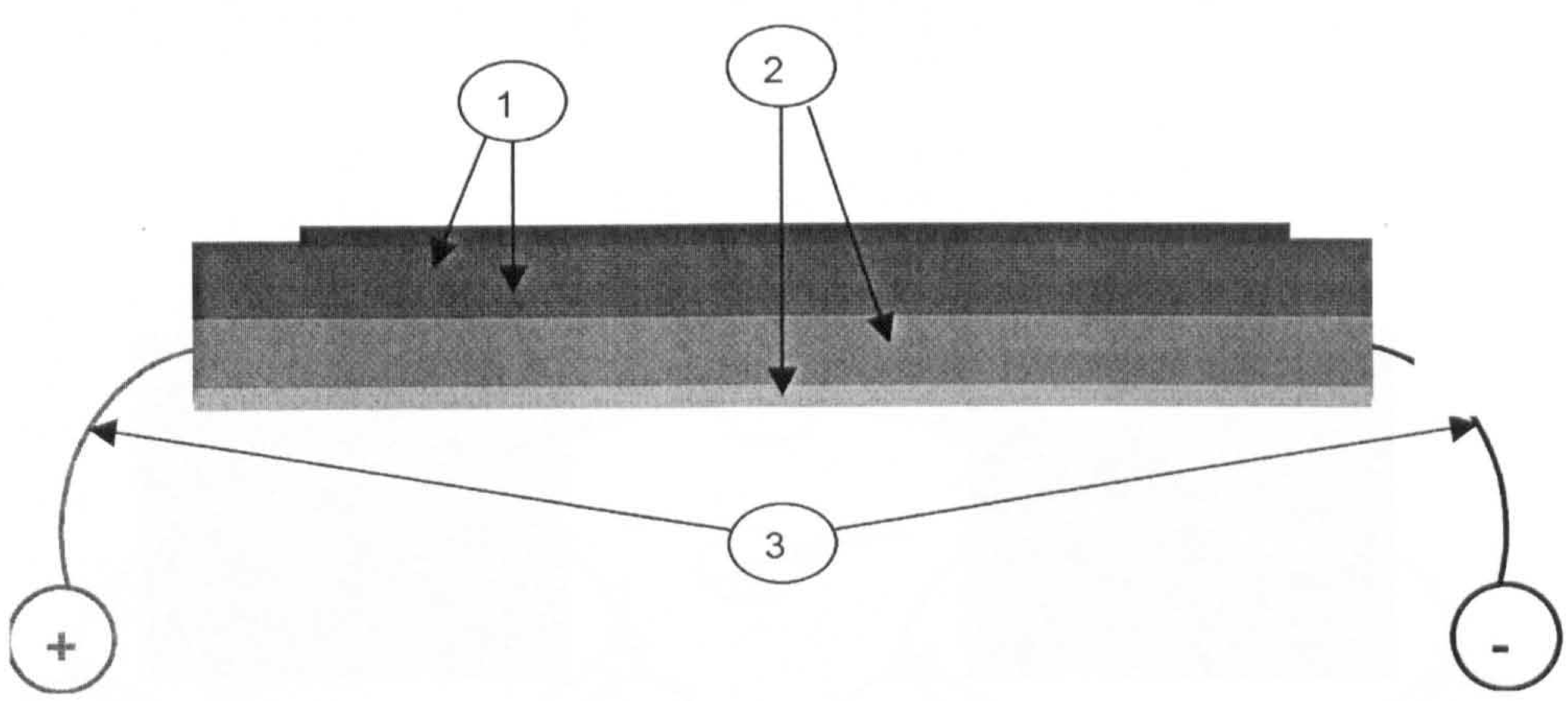
Woven electro-textile wall panels by textile designer Maggie Orth.

154, 155 Woven fabric before and after the colourchange has taken place.

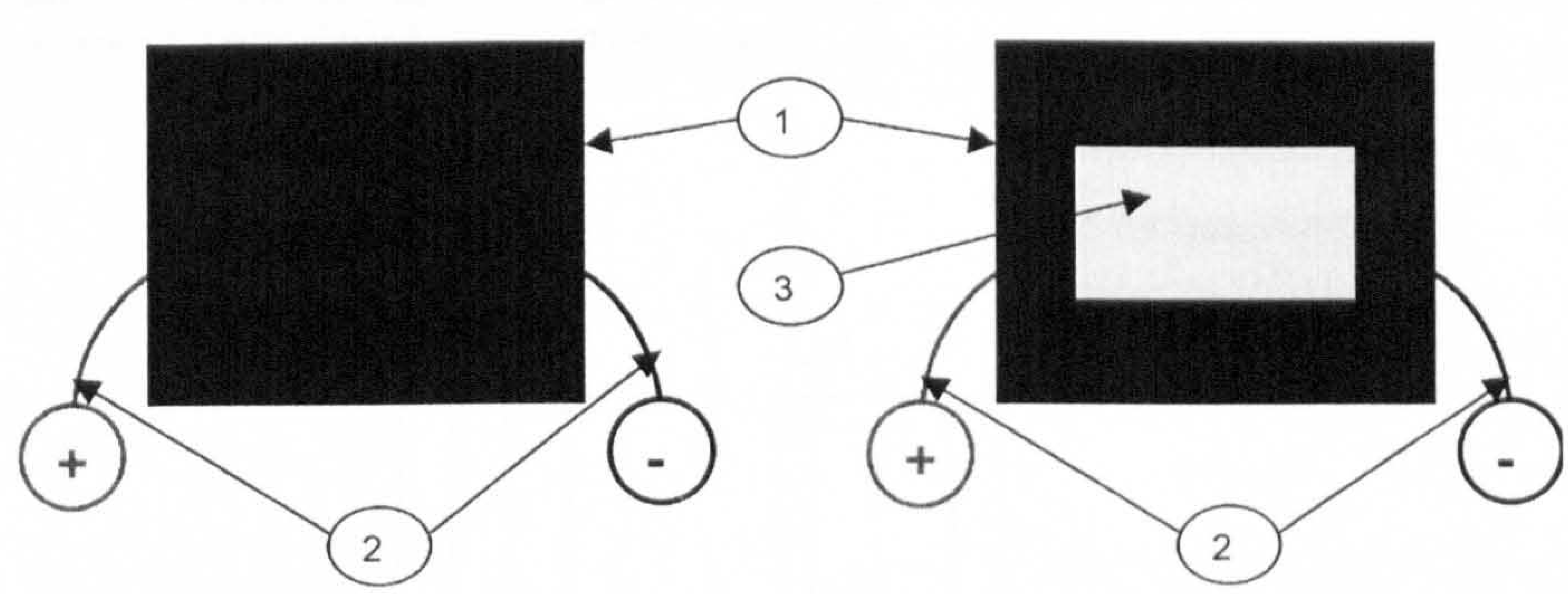
154, 155



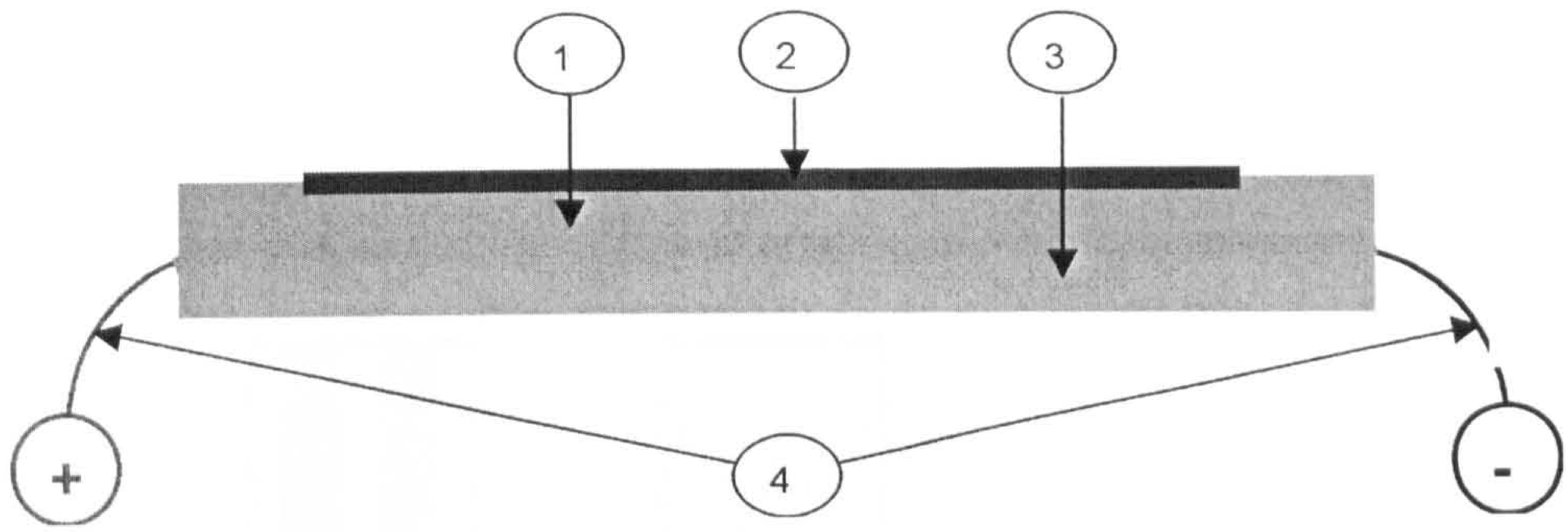
156 (A) A cross section of a basic layered construction used to make colourchange fabric. 1 – textile or other substrate, 2 – TLCI or TCI coating on the substrate, 3 – a layer of conductive ink, which has high resistance on the same substrate, 4 – wires leading to the positive and negative terminals of a power supply.



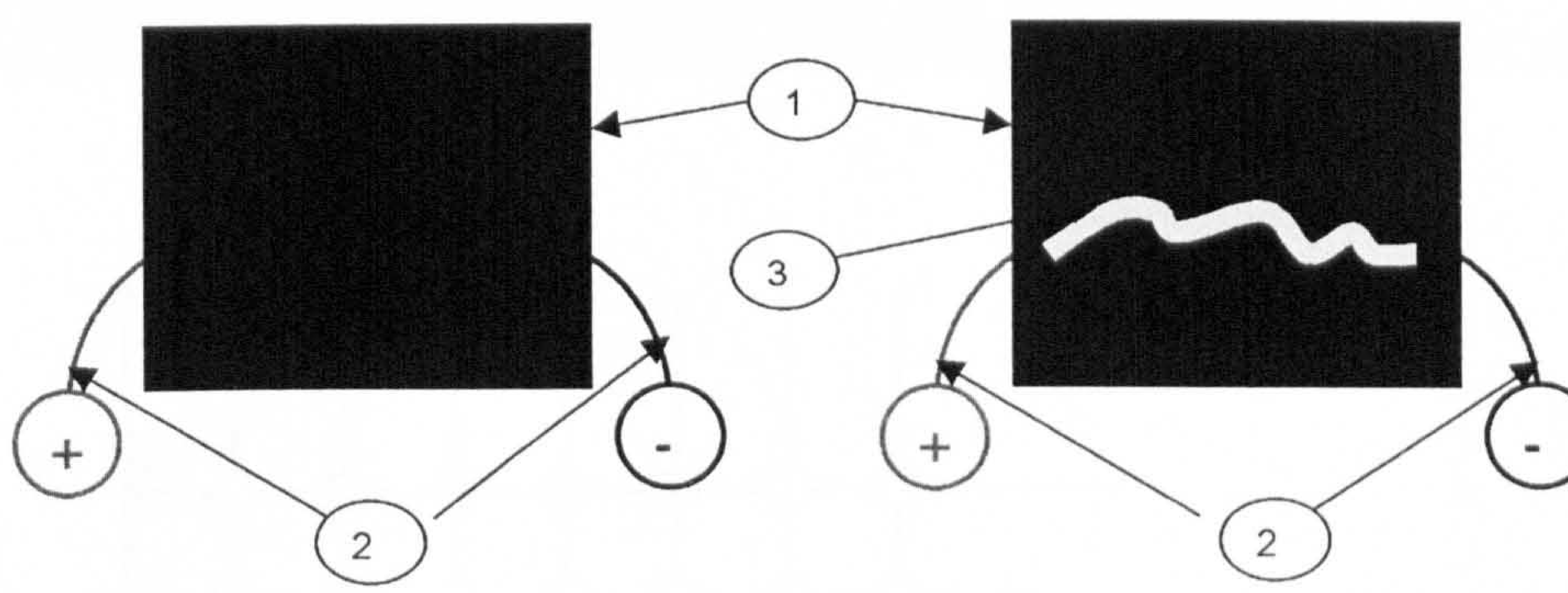
156 (B) A cross section of a basic layered construction used to make colourchange fabric. 1 – textile or other substrate coated with TLCI or TCI, 2 – textile or other substrate coated with conductive ink, which has high resistance, 3 – wires leading to the positive and negative terminals of a power supply.



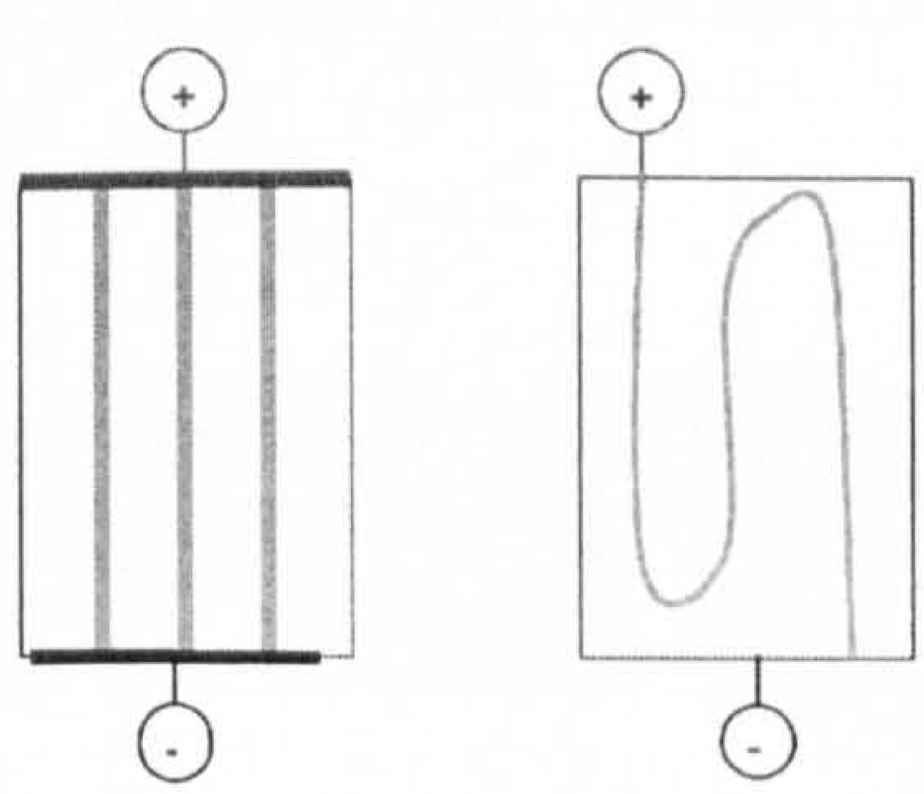
156 (C) A frontal view of a basic layered construction used to make colourchange fabric. 1 – textile or other substrate coated with TLCI or TCI; beneath the textile or other substrate coated with conductive ink, which has high resistance (see Figures 2a and 2b), 2 – wires leading to the positive and negative terminals of a power supply, 3 – VERSICOLOUR effect after a certain voltage and amperage has been passed through the conductive ink printed in the shape of a square by heating up the textile substrate coated with thermochromic ink.



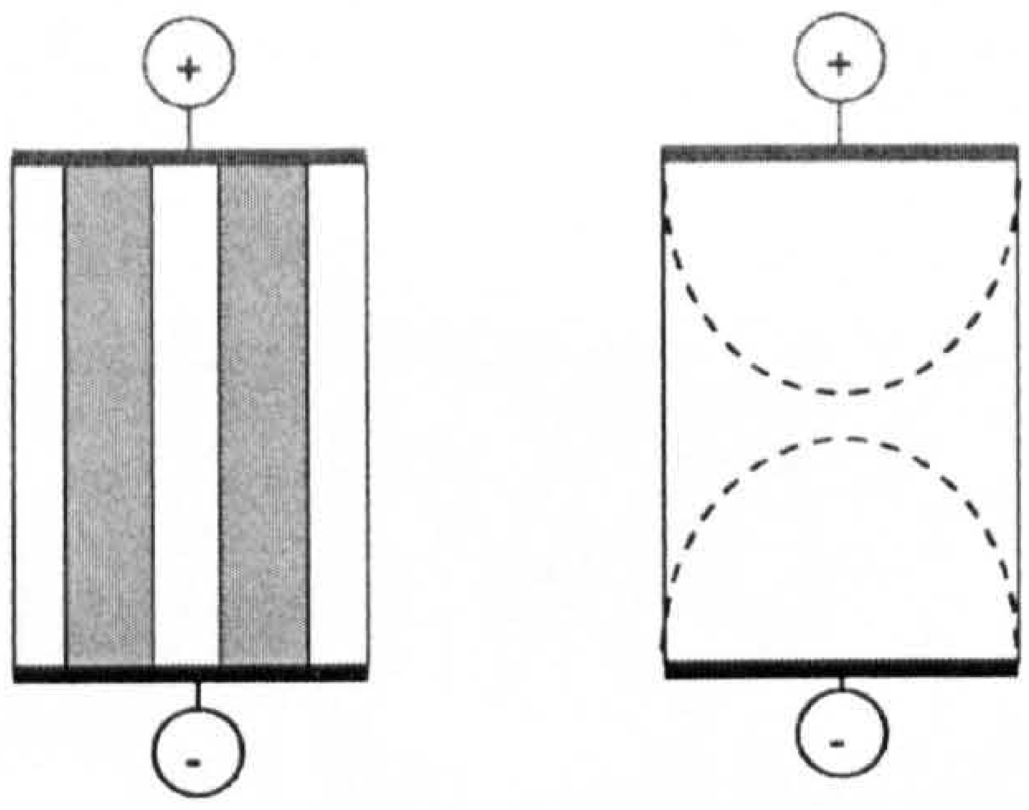
157 (A) A cross section of basic layered construction used to make colourchange fabric. 1 – textile or other substrate, 2 – TLCI or TCI coating on the substrate, 3 – thin conductive thread, which has high resistance incorporated into the substrate, 4 – wires leading to the positive and negative terminals of a power supply.



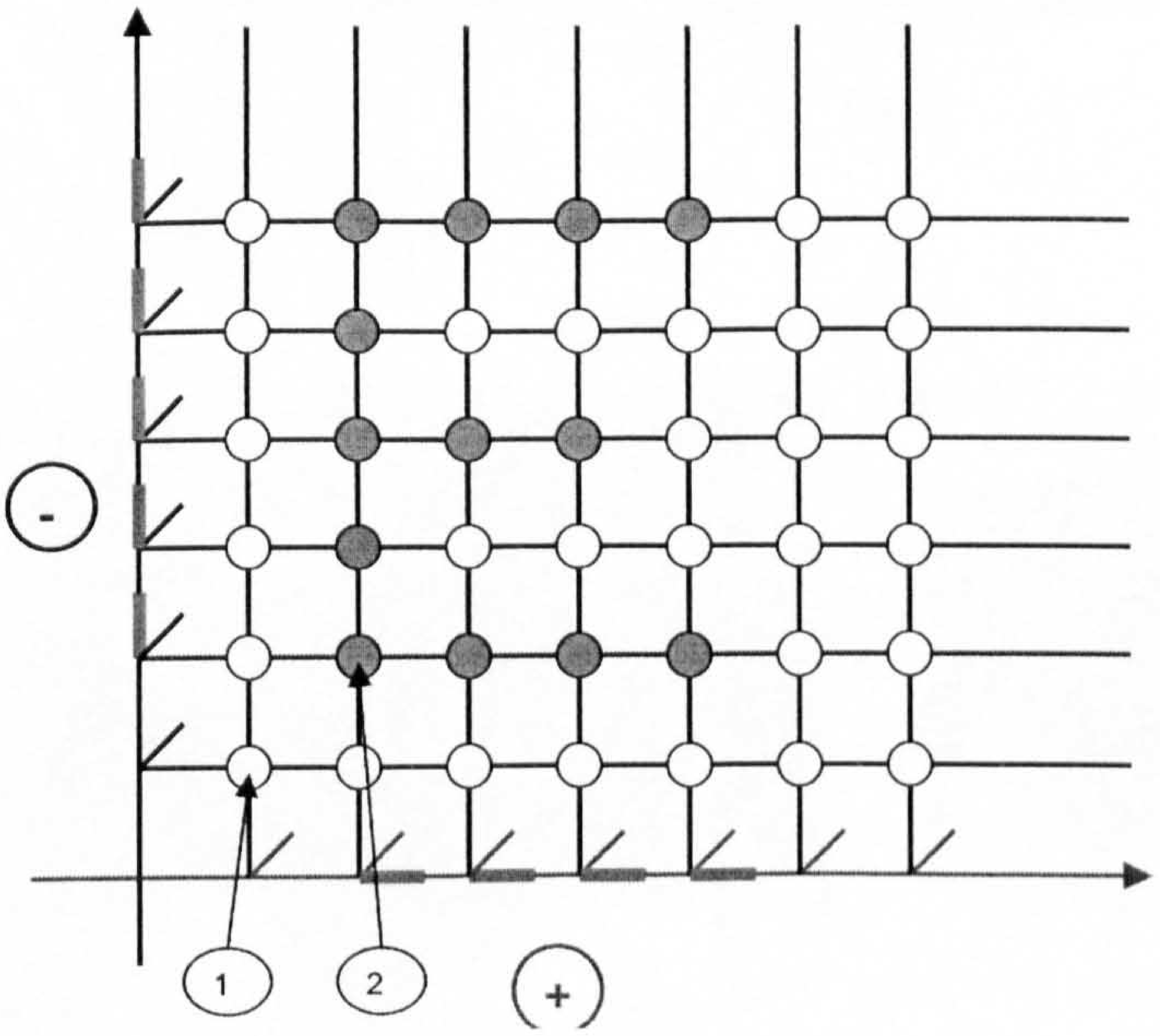
157 (B) A frontal view of basic layered construction used to make colourchange fabric. 1 – textile or other substrate coated with TLCI or TCI; beneath conductive thread, which has high resistance and is incorporated into the substrate, 2 – wires leading to the positive and negative terminals of a power supply, 3 - VERSICOLOUR effect after a certain voltage and amperage has been passed through the conductive thread.



158 (A) and 158 (B) Printed conductive stripes (158 A) and freely arranged conductive thread (158 B).



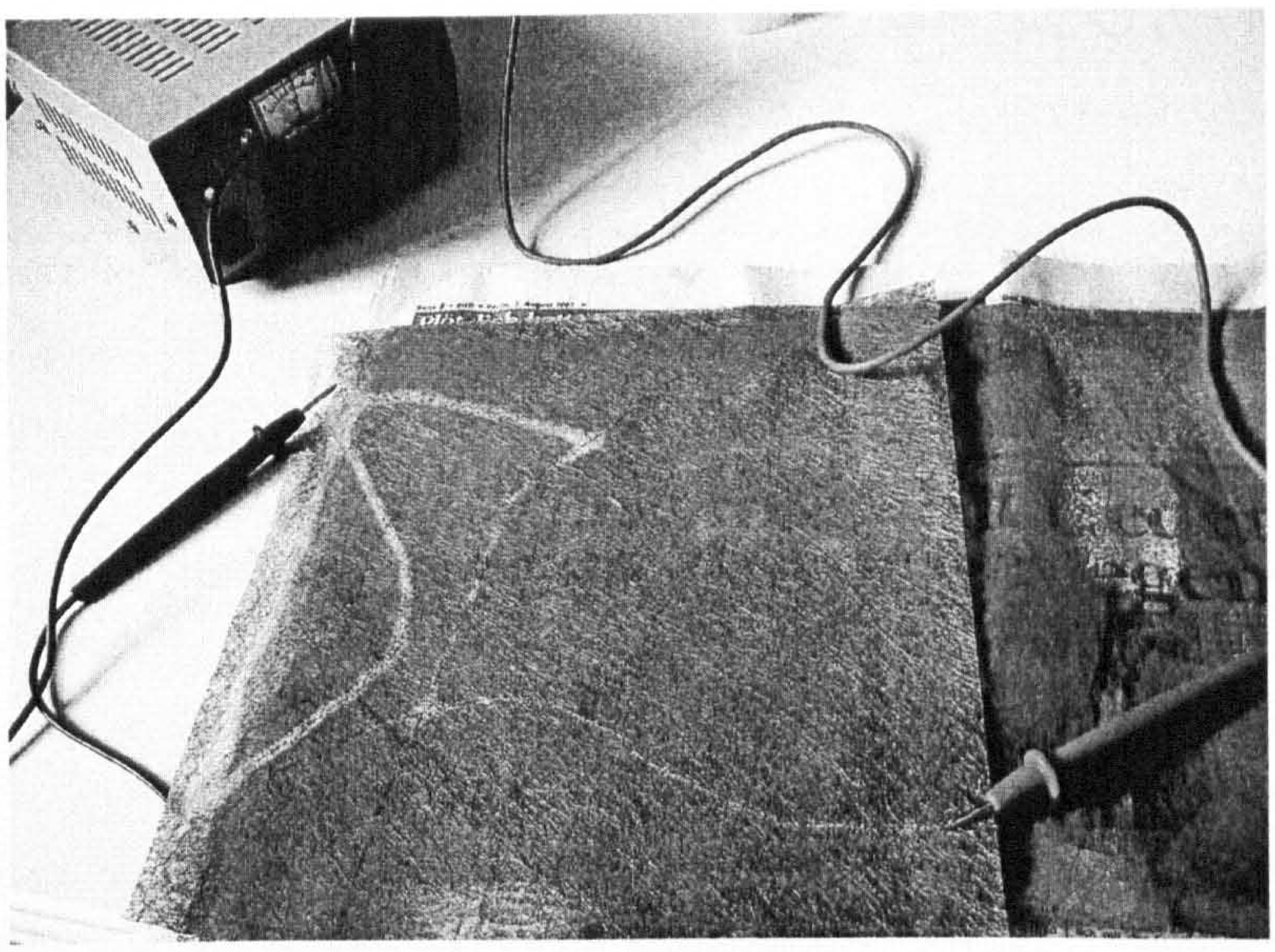
159 (A) and 159 (B) Printed conductive blocks (5a) and overall printed conductor ink (5b). The two half circles are signifying the increasing / radiating heat created when a certain voltage and amperage passes through the resistive ink and warms the substrate up to a uniform temperature over the entire area, displaying a uniform colourchange effect.



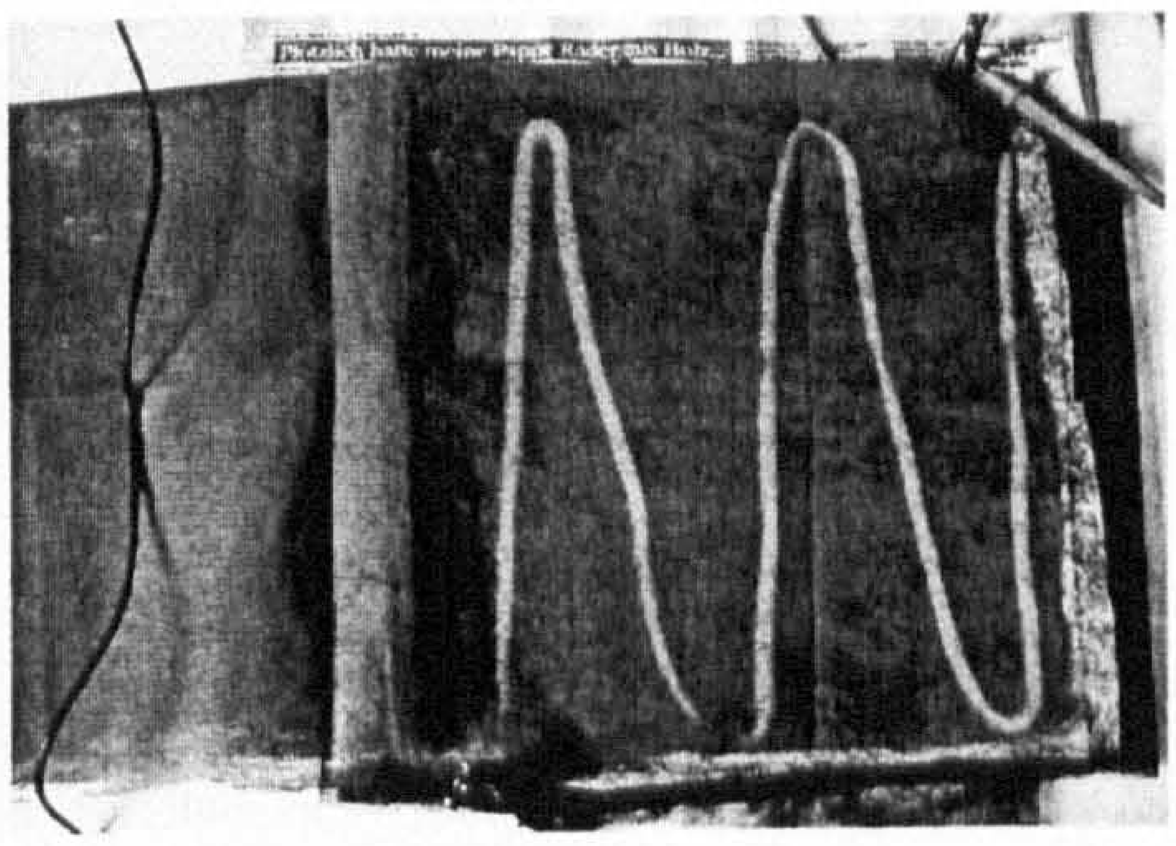
160 A basic schema for the VERSICOLOUR concept, potentially using a digital control system directed by a computer programme that can send signals to conductive patches located on a X-Y matrix, in order to switch on or off each patch independently. Here as an example: the letter 'E' is activated. 1 – closed circuit, 2 – open circuit.

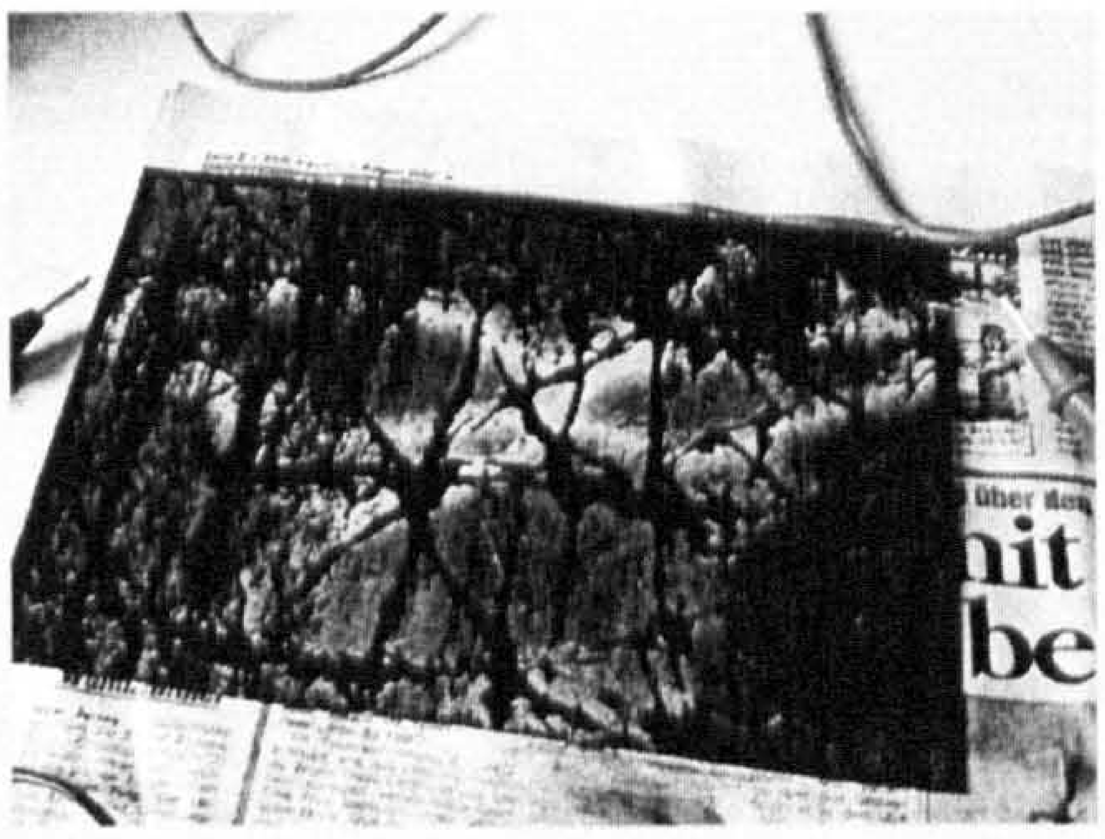
11.1.3 EXPERIMENTS

Technical experiments were conducted in order to develop and to facilitate the incorporation of the VERSICOLOUR system in my textile membranes. The following images are showing some examples of the work in process.



161





162, 163

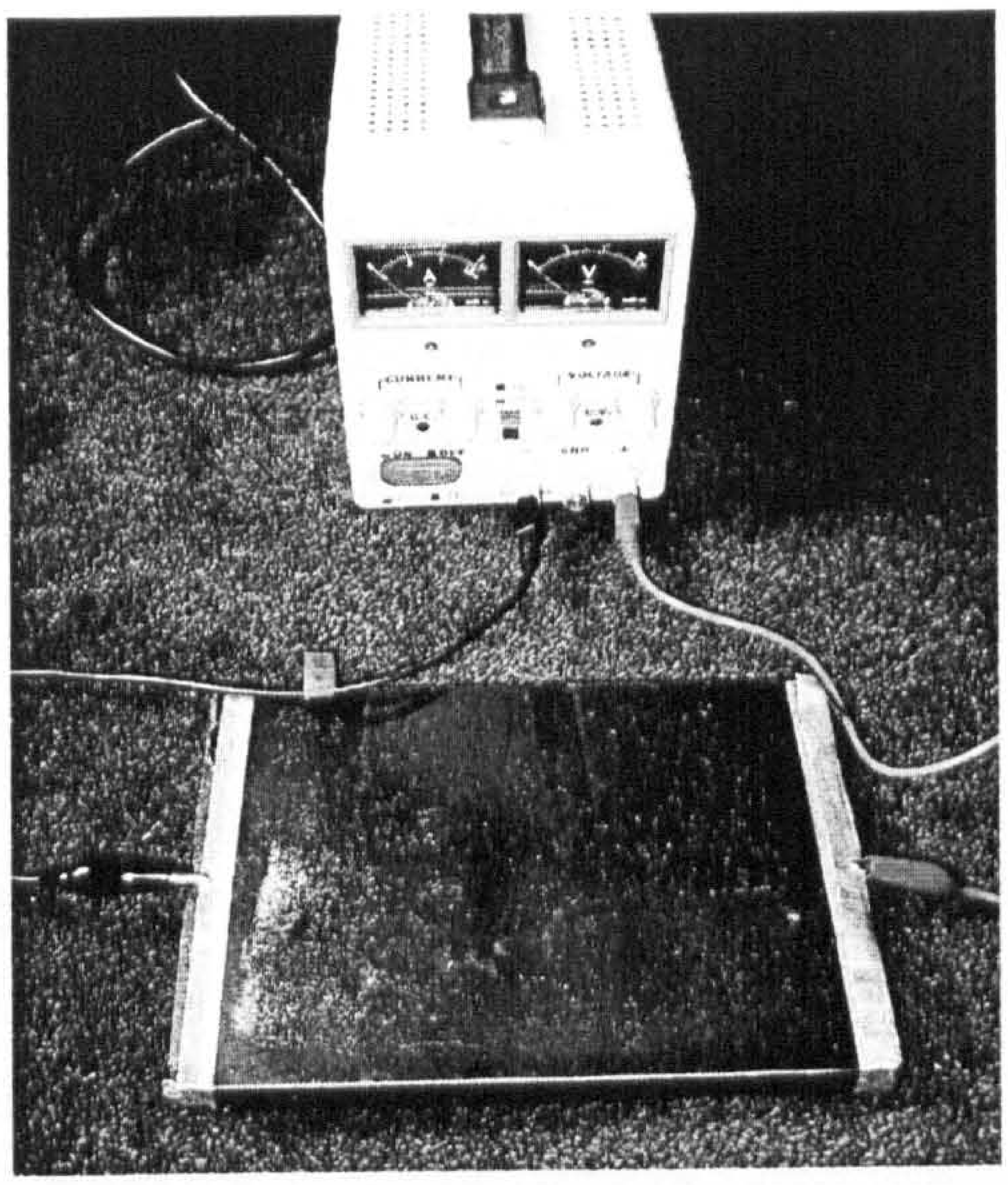
Tests.

VERSICOLOUR textile samples: experimental work in process.

161, 162 Use of base material printed with TCI.

163 Use of base material printed with TLCI.

In both cases a freely arranged conductive wire is used in order to achieve linear drawing patterns.



Tests of the VERSICOLOUR textile samples: experimental work in process.

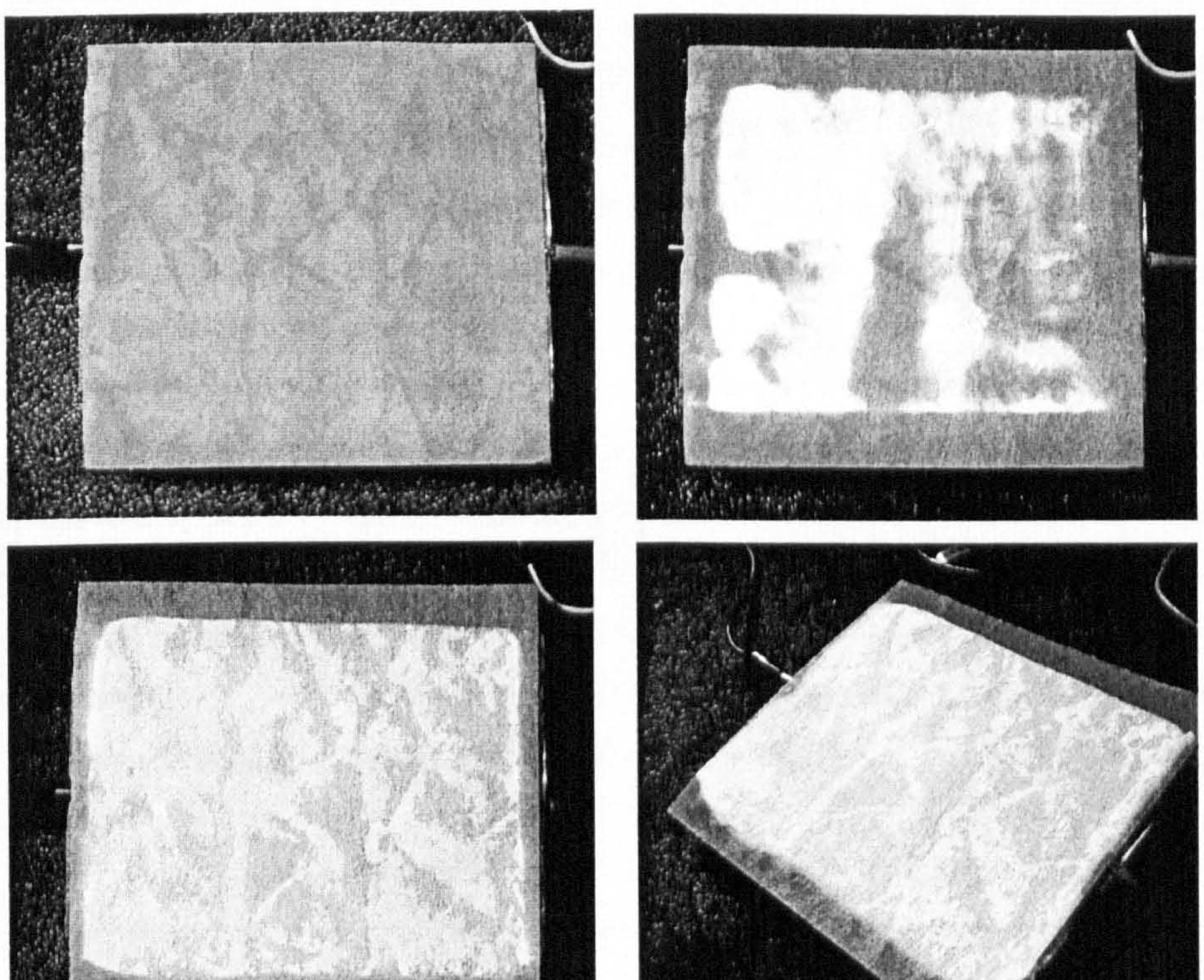
164 Base panel with overall printed conductor ink (carbon) and wires attached leading to the positive and negative terminals of a power supply.

165 (A) Fabric substrate treated with TCI; closed circuit.

165 (B) Open circuit; when a certain voltage and amperage passes through the resistive ink and warms the substrate up, the heat radiates creating a colouchange effect.

165 (C, D) Open circuit; the resistive ink has warmed up to a uniform temperature over the entire area, displaying a uniform colourchange effect.

164



165 A, B, C, D

11.1.4 TCI MULTICOLOUR CHROMIC DESIGN SYSTEM

During the experimental stage of my research, I have tested many different ways of using thermochromic inks in order to obtain new design solutions, new optics and new colourchange effects. In the course of my technical trials I have discovered that, besides the conventional use of TCI (only one chromatic colour/temperature type per design), it is possible to enhance the colourchange experience by applying several layers of different colours and temperature type inks. This has to be done systematically, keeping in mind that the lightest colour has to be the one that is applied to fabric first, followed by other darker colour shades and finishing with the darkest. Additionally, ink with the highest activation point temperature should be of the lightest colour shade and ink with the lowest activation point temperature should be the darkest one, in order to sustain the MULTICOLOUR CHROMATIC DESIGN system (Table 8).

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4
fabric base colour (white)	light colour shade (yellow)	darker colour shade (red)	very dark colour shade (black)
BASE COLOUR | this level appears after LEVEL 3 colour has reached its threshold temperature 36 C°	TYPE 35 highest activation point temperature 27 C° | colour disappears above 36 C°	TYPE 25 medium activation point temperature 22 C° | colour disappears above 31 C°	TYPE 20 lowest activation point temperature 16 C° | colour disappears above 26 C°

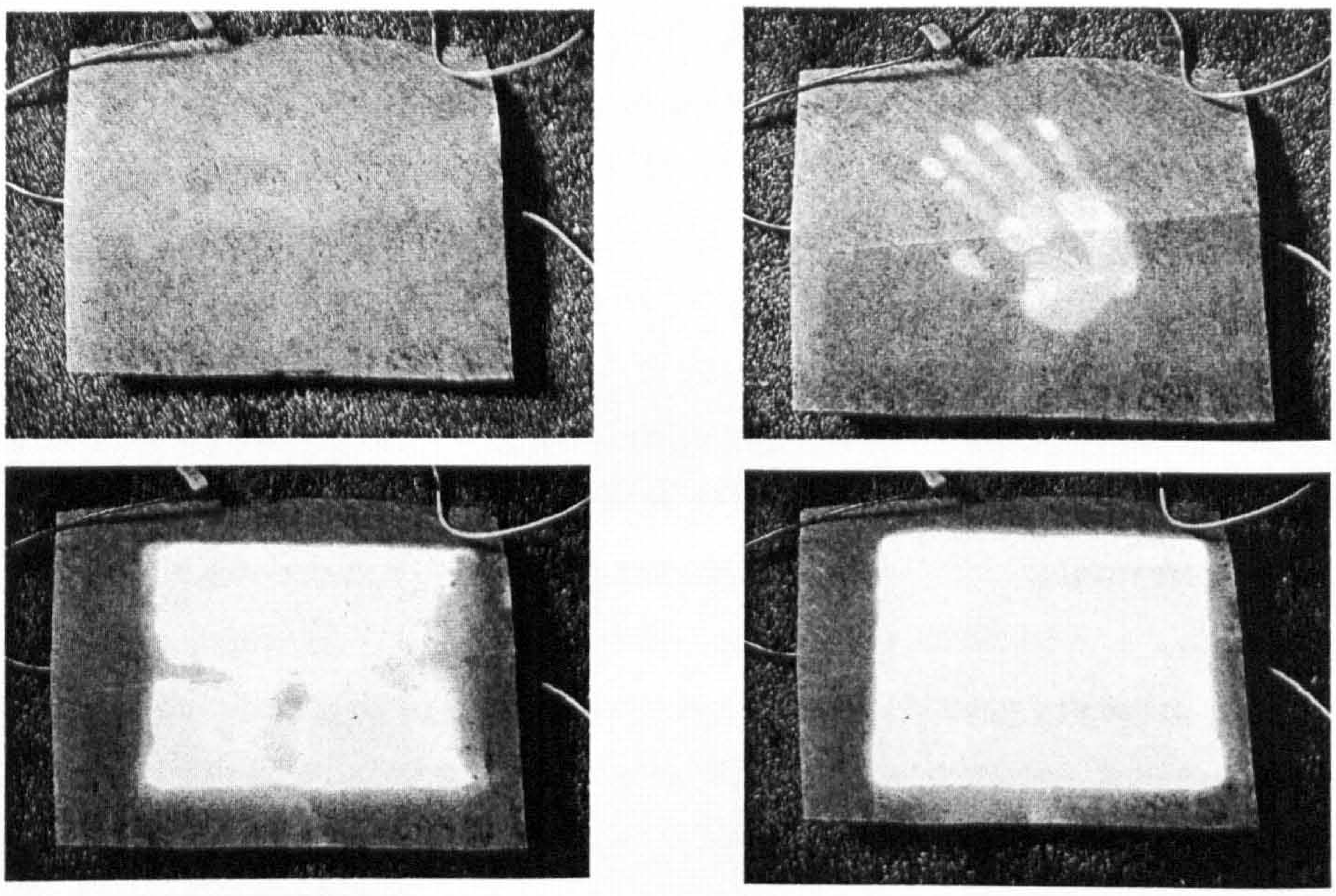
Table 8
An example use of thermochromic inks for multicolour chromatic design solutions, describing the relationship between TCI colour grades and their temperature types. In this case the TCI temperature types/ranges are as offered by the company Matsui.

The MULTICOLOUR CHROMIC DESIGN SYSTEM can have various visual outputs depending on which colour/temperature type 'level' is activated as seen in Figure 166. Accordingly, if 'level 4' is activated – black disappears, revealing the red 'level 3'. If 'level 3' is activated – the yellow 'level 2' appears, and then if this is activated – 'level 1' becomes visible, which is the base colour of the treated substrate. The base can also carry a pattern, but it cannot be darker in colour than 'level 2'. For example, a white and light yellow pattern would fit within the system described in Table 8 without disabling it.

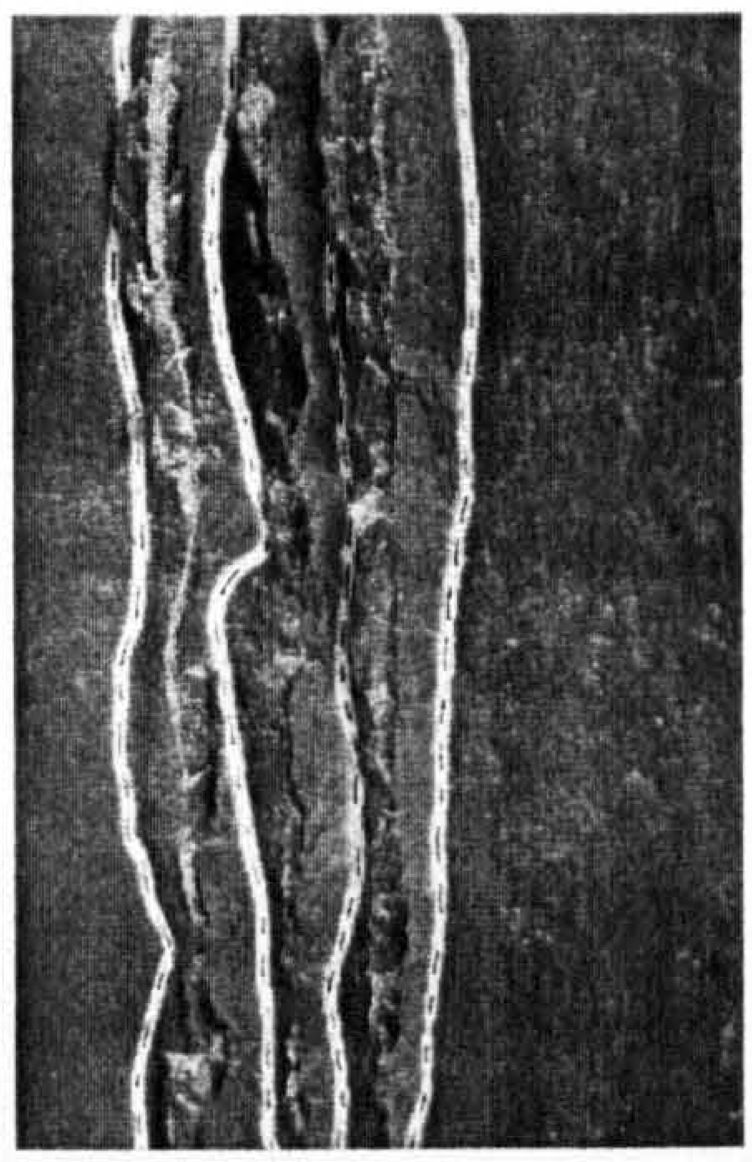
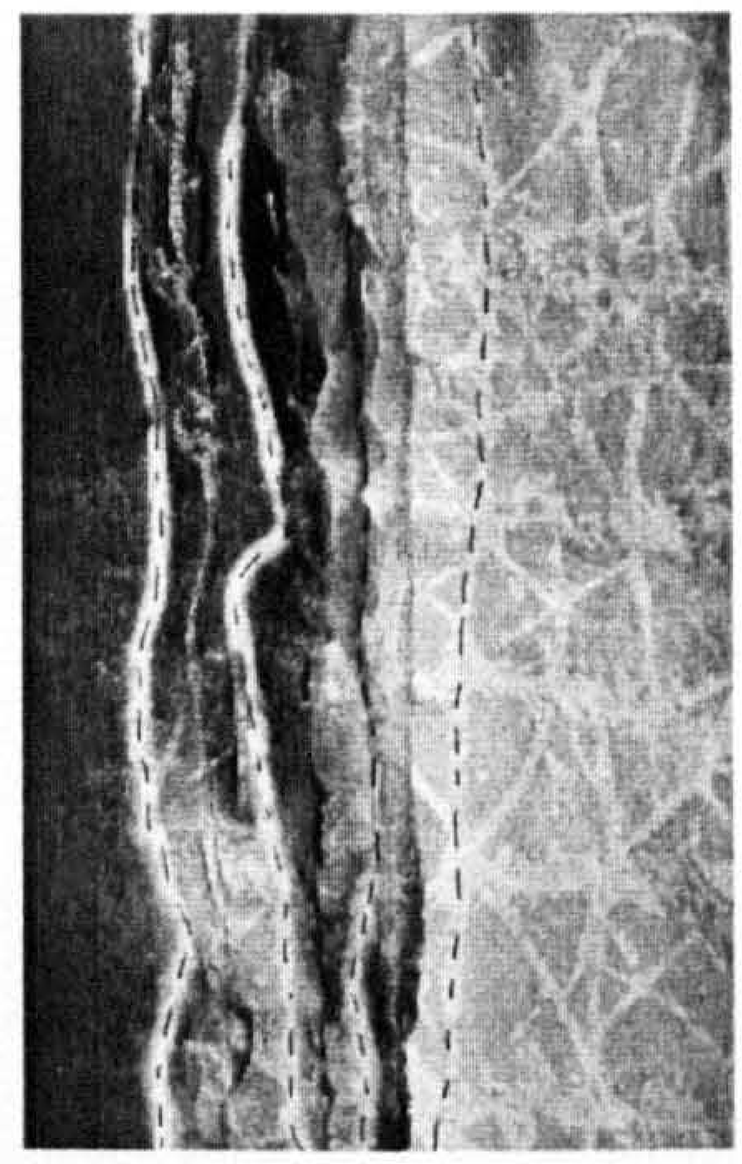
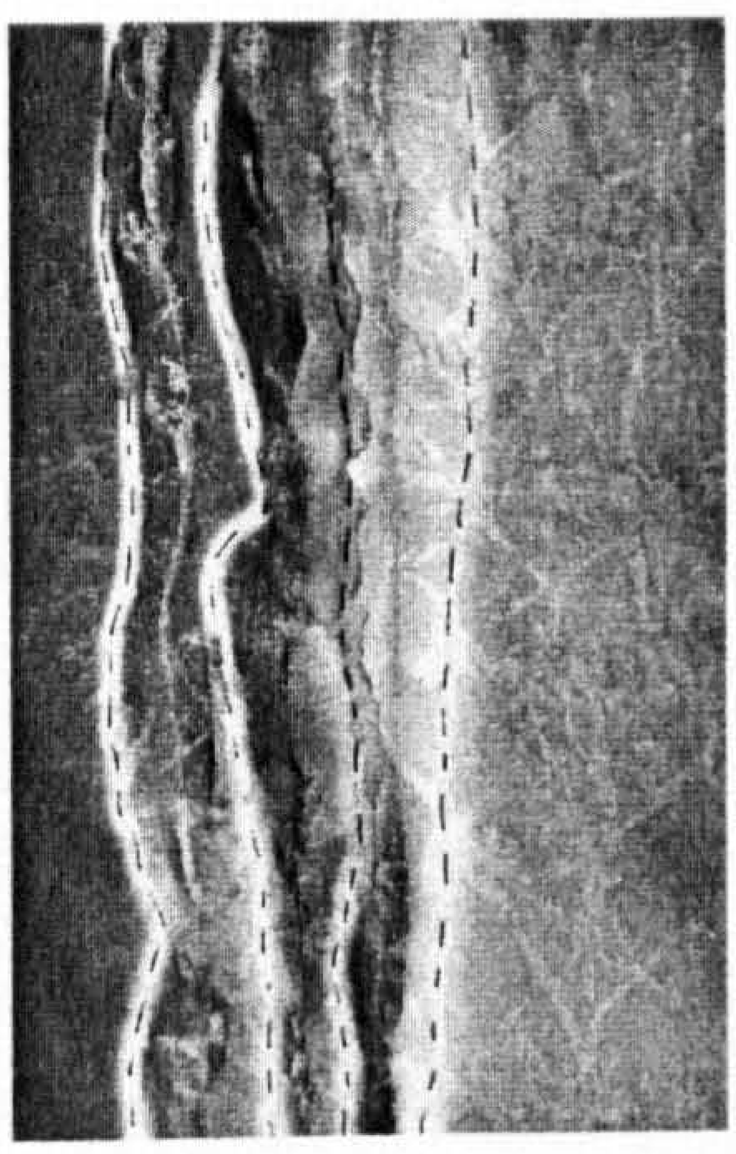
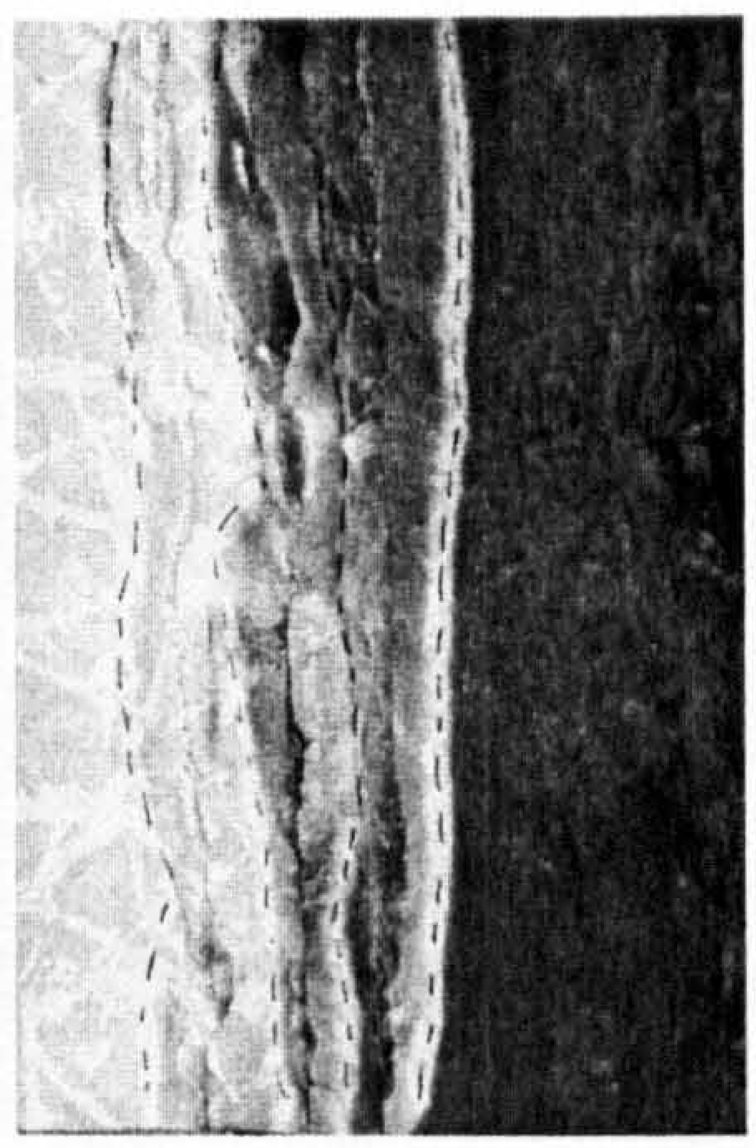
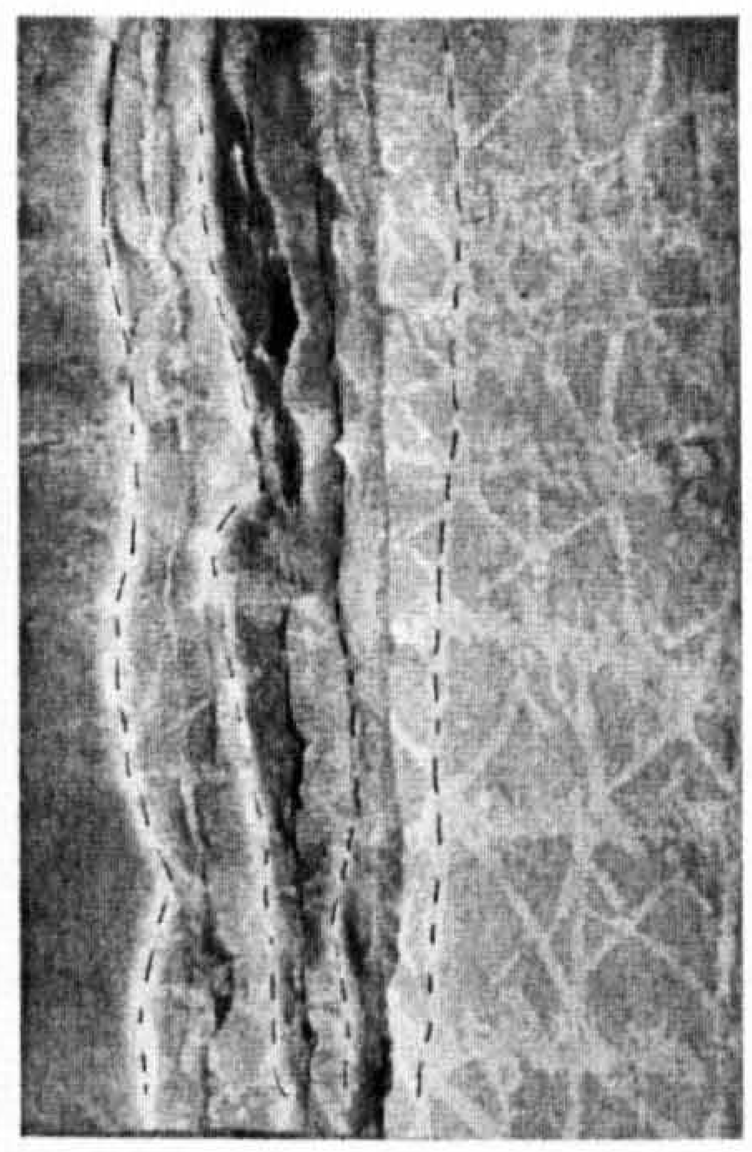
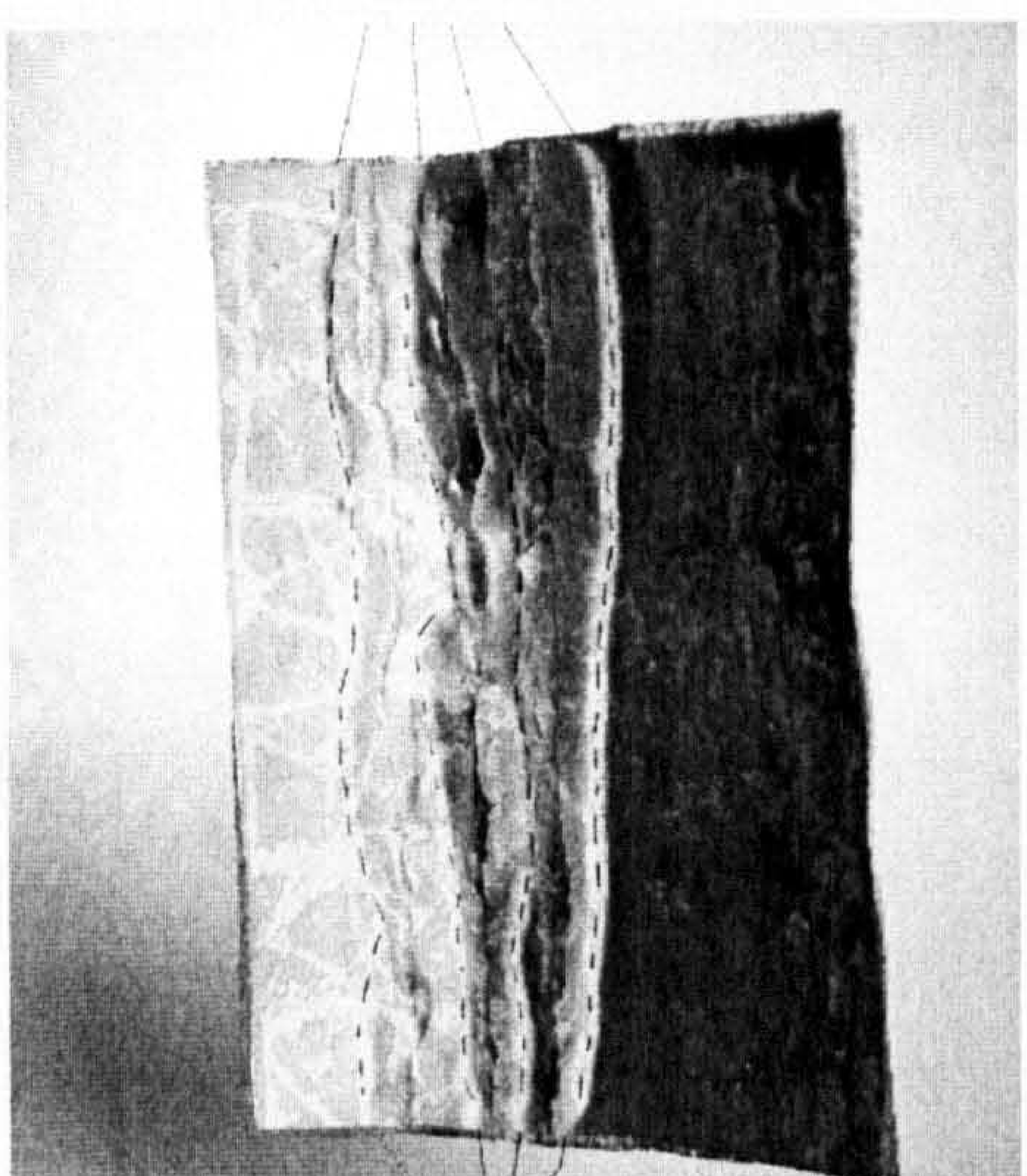
The activation of the MULTICOLOUR CHROMIC DESIGN SYSTEM takes place in response to the intensity of temperature applied to the fabric treated with TCI, as described previously (11.1.1). At lower temperatures, it can be activated by ambient temperature changes as well as in response to human body heat. For higher TCI temperature ranges an activation using the VERSICOLOUR system is needed (11.1.2). With the support of adequately pre-programmed electronics set to the threshold temperatures of selected TCIs (example Table 5), sophisticated colour-play designs can be achieved.

The MULTICOLOUR CHROMIC DESIGN SYSTEM offers a wide spectrum of designing possibilities and is no longer limited to two colours. The system outweighs the previously described limitations typical to TCI (colour on/off), and compares better with TLCI, which goes through the whole spectrum of colours after the activation temperature is reached. Actually the MULTICOLOUR CHROMIC DESIGN SYSTEM provides a larger number of colour variations that can be chosen by the designer, as opposed to the more sophisticated but predetermined and UV light unstable TLCI colour system.

Taking these aspects into account, it is possible to suggest that the MULTICOLOUR CHROMIC DESIGN SYSTEM could prove to be more effective for advanced chromicolour designs, being easier to use, having a wide range of colourchange options and being relatively UV stable as well as being less expensive.



166 A, B, C, D The TCI MULTICOLOUR CHROMIC DESIGN SYSTEM.
Textile samples: experimental work in process.
166 (A) Fabric substrate treated with TCIs (closed circuit). Level 1 = yellow base fabric, level 2 = a layer of orange TCI, level 3 = a layer of brown TCI (as in Table 8);
166 (B) Activation of the level 2 using bodily warmth (closed circuit);
166 (C) Activation of the level 1 using electric heat (open circuit);
166 (D) Activation of the level 1 completed (open circuit).

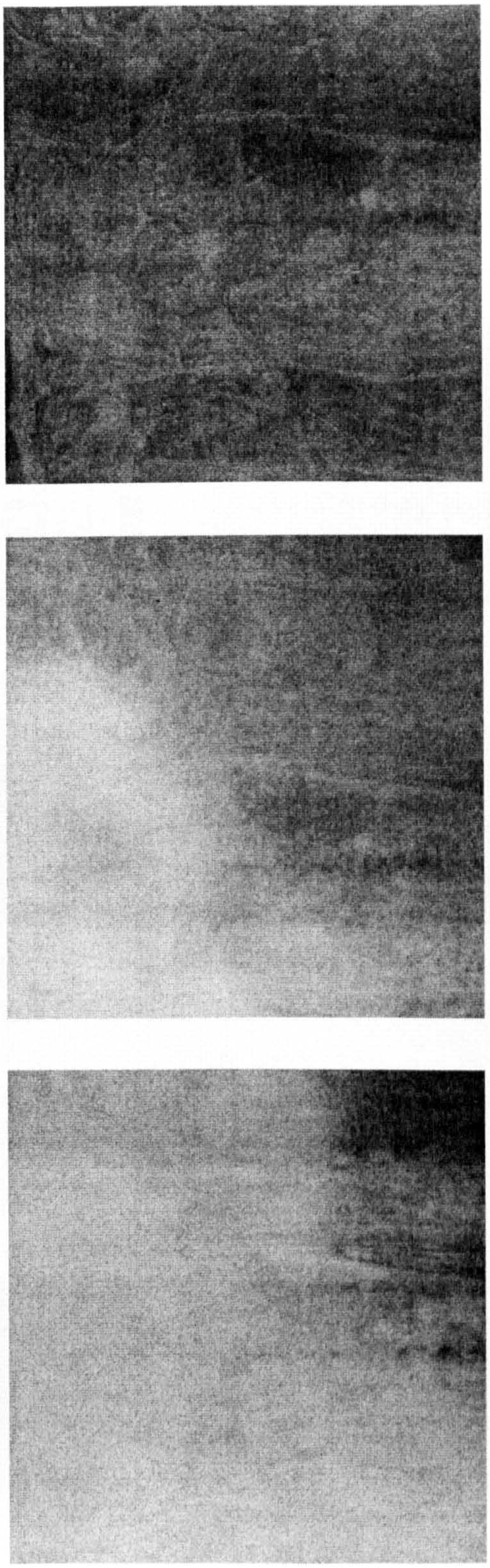
Tests of the TCI MULTICOLOUR CHROMIC DESIGN SYSTEM.

167 (A - G) Images of the LIVING MEMBRANES are showing the pulsating colourchange plays. The operating principle of this work is based on the colourchange properties of thermochromic inks reacting to increasing or decreasing heat, initiated by electric stimuli. The colourchange effect is controllable and reversible.

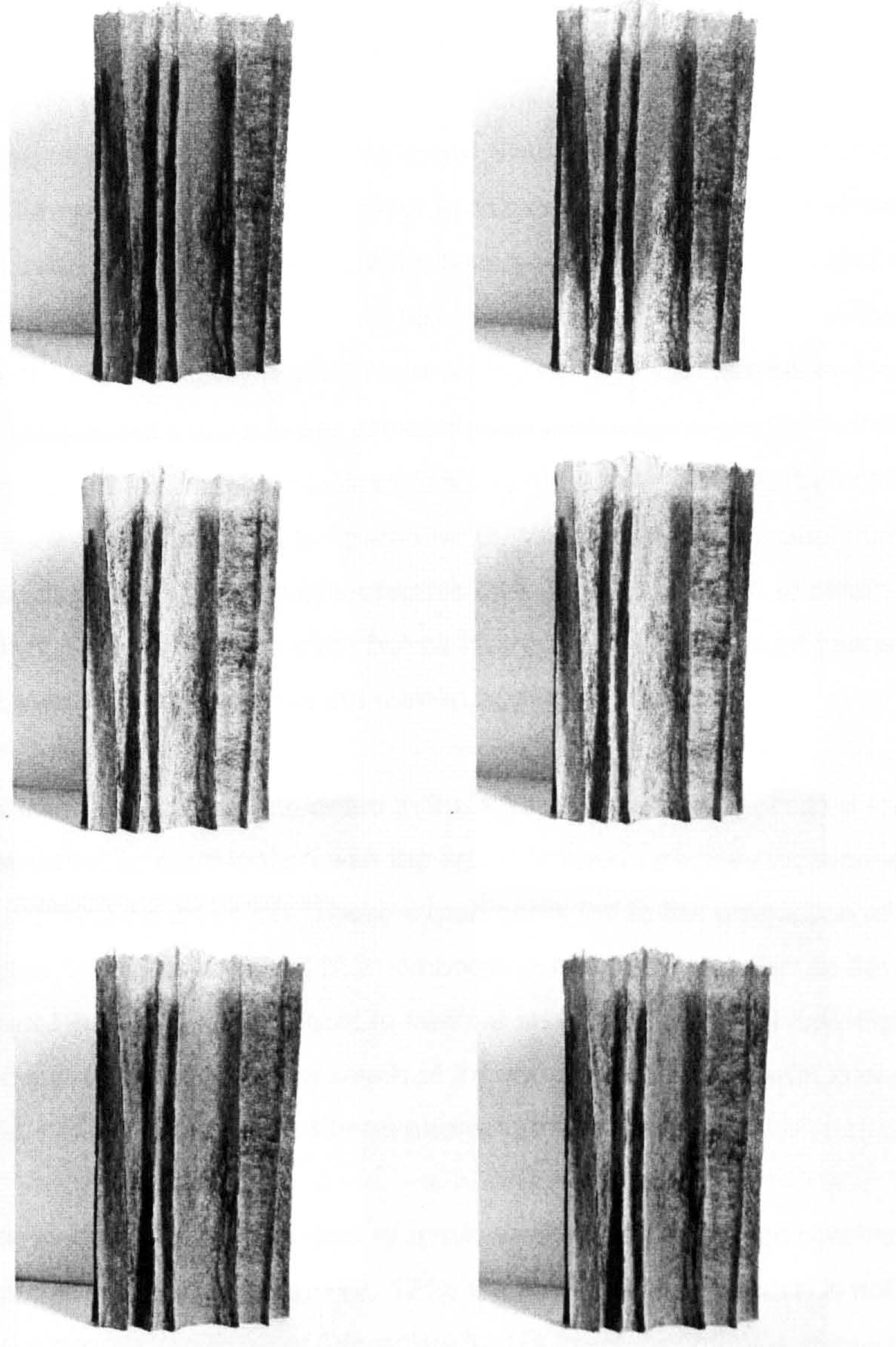
The materials used for the production of this work are polyester nonwoven, conducted stainless steal filament yarn and TCI.

The techniques used for the production of this work are screen printing, painting, embroidery.

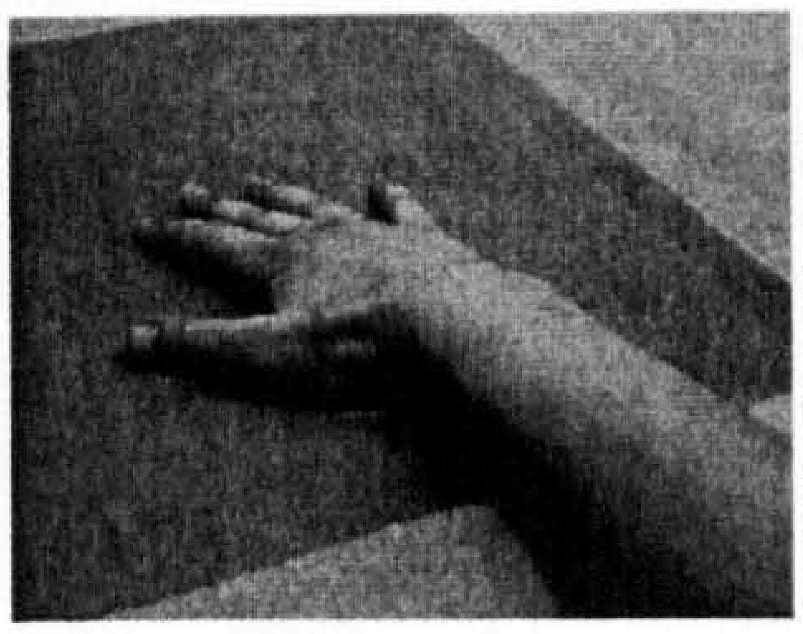
167 A, B, C, D, E, F, G



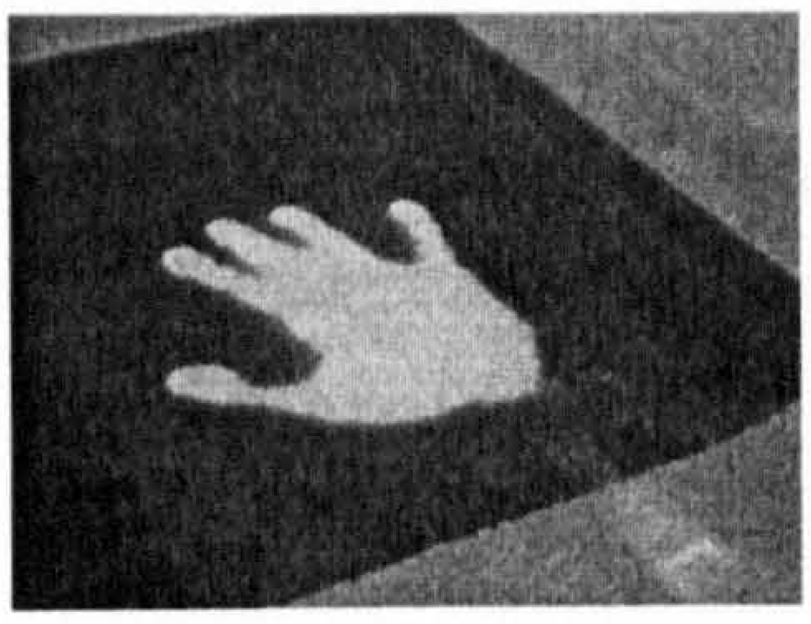
168 If stimulated with hot air, thermochromic textiles gradually change their colour by achieving full transparency at the threshold temperature



169 A, B, C, D, E, F Prototype for a heat-sensitive textile installation, which responds to changing environmental conditions. The textile object, treated with thermochromic ink, functions as a reversible indicator of fluctuating room temperatures by changing colour. The colourchange takes place in pulsing wave-like movements across the whole object so that it becomes virtually 'alive'.



170, 171 An example of 'touch formulated' textiles that respond to human warmth.



170, 171

11.1.5 TOUCH FORMULATED TEXTILES AND OTHER EXPERIMENTS

During the course of research alternative ways of working with thermochromic inks were tested. Given that TCIs change colour in response to a change in temperature, experiments with simple household heating systems, such as hair dryers and electric heaters, were undertaken. Textile substrates, treated with TCI with an activation point temperature at 22°C or slightly higher, were largely used so that normal ambient room temperatures would not influence the colourchange process unexpectedly. If stimulated with hot air, thermochromic textiles gradually change their colour by achieving full transparency at the threshold temperature. By varying the rhythm and intensity of the hot air strain applied to the thermochromic surfaces it is possible to obtain various 'pulsating' colourchange effects as the hot air moves around in different intensities, drawing parallels with processes in the human body (see Fig. 168).

For this part I was particularly interested in the idea of using uncomplicated low-tech household systems, in combination with the smart temperature sensing thermochromic inks, to produce an art object. These experiments led to the production of the textiles installation 'Pulsating Object' (12.2) embodying an analogy of skin as the living sensory shell of the body which reacts to internal and external stimuli (see Fig. 169). A similar concept involving the stimulation of thermochromic textiles with cool air is also possible, however this has not been attempted in this research.

Another approach was to use the heat of a human body to activate colourchange in thermochromic textiles (see Fig. 170, 171). On its own, this approach is not new. However, used together with other interactive textile functions integrated into the same substrate, 'touch formulated' fabrics offer a new experience for our sensorium as described later.

In order to produce 'touch sensitive' textiles, thermochromic inks with an activation point temperature at 22°C were proved to be appropriate. However, if such textiles are being produced for wall coverings, inks with a lower activation point temperature should be considered due to the natural coolness of wall structures, which influence the end result.

11.1.6 SUMMARY

The new concept of the VERSICOLOUR system offers a wide range of flexible designing possibilities and a potential for various end uses, such as functional wall and ceiling coverings for building interiors, space dividers, wall hangings, textile screens, furniture textiles as well as functional and decorative textiles for apparel and accessories. The concept is based on the analogy of flushing human skin mechanisms sustained by electric signals sent by our nervous receptors in our sensory system and changes in blood circulation when our body is dealing with excess heat.

Being electrical systems the VERSICOLOUR surfaces can be programmed to perform controllable 'pulsating' colourchange effects and patterns, in sections or overall, mimicing characteristics of living skin 'technology'. In the future, the system needs to be developed further by becoming digital, whereby computer software would direct the colourchange processes (computer = brain). For more sophisticated technology displays, where heating patches are arranged on an X-Y co-ordinate grid (as seen in Figure 160), a digital control system running the software LABVIEW made by National Instruments can be used. The controller of each patch is directed by the computer program, which can send signals to switch on or off each patch independently.

The VERSICOLOUR design could introduce flexibility into environments that are typically fixed in terms of colour and space and cannot be easily redecorated. The VERSICOLOUR system offers the possibility of reversibly changing the entire ambience and colour design of an interior when, where and to what extent it might be desired. This aspect might be particularly interesting for public environments such as bars, restaurants and clubs where the ambience, novelty aspect and comfort of the customers mean commercial success or failure. It means that the same place can virtually change its appearance or its 'skin' as many times as it is needed during the day, to serve the needs of different customers in different social contexts.

Such a concept would be also attractive for private environments - home interiors or luxurious car interiors. It has potential to offer a unique sensory experience that could enhance people's emotional and physical wellbeing through colour therapy, and also provide a unique personalised environment. Other applications eventually might include hospitals, health clubs and resorts, cosmetic salons and fitness clubs with harmonised colour plays alongside tactile, olfactory and audio experiences.

In places like kindergartens and other environments designed for children, 'touch formulated' colourchange surfaces would be particularly applicable. Such 'touch formulated' surfaces would invite children to interact with objects in a different tactile-visual way by leaving their own personal body prints on each object's surface. In this mode, they can experience their body, their senses and their environment in a new way. When discussing the concept and its acceptability with Monte C. Magill, Business and Technology Director from Outlast Technologies, who is interested in producing novel wall coverings, I received the following answer: 'As for the market size and acceptability I can only say that there should very likely be a market. After all, people like colours and like to feel comfortable.'[4]

The VERSICOLOUR system in combination with the MULTICOLOURED CHROMIC system, being highly flexible and variable systems, offer the potential to design 'tailor-made' personalised environments for people's specific physiological and emotional needs. Symbolically, psychologically and physically, this extends their senses by creating sensory 2nd and 3rd skin (clothing and interior). The colourchange system can be controlled by analogue or digital systems and activated depending on the technology and electronics behind them, using an on/off switch, remote control, timer or by a command sent from a computer.

In the context of our inevitable future, when wearable technologies and the intelligent house will become a standard in our lives, personalised interactive design systems seemingly will be in high demand. Even the most conservative forecasts put sales of wired clothing at $100 million by 2006; others think the market could be worth $1 billion by then.[5] Electronics in our garments will be able to sense and communicate our mood, blood pressure and state of health to our personal computer as soon as we enter our house or office. Our personalised PC will take care of the rest by providing the right ambience for us with calming and curative colour-plays and soothing, aroma-therapeutic smells....

11.2 OLFACTORY, FRESHNESS AND FILTERING TEXTILES

As discussed in Chapter (05.4) the sense of smell is our most powerful sense, having a tremendous impact on our moods, behaviour and relationships. Humans themselves are smelly beings and, like other mammals, each of us possesses an individual odour signature. Our pheromones that communicate our very biological essence, are detected on a sub-conscious level by others. However, only in the 1990s was a substantial amount of research conducted into the impact of the olfactory aspect on our lives initiated in the US, Europe and Japan. The effects of fragrances were measured 'on feelings, emotions and moods as well as electrical activity in the brain, physiological parameters such as heat rate and skin conductance, cognitive functions and voluntary and involuntary behaviour.'[6]

In the recent decade scientists and designers have come up with some exciting concepts affecting our sense of smell and therefore our wellbeing. Sensory designer Dr. Jenny Tillotson, who is working on 'electronic nose technology' in collaboration with perfumers, chemists, medical technologists and nanotechnologists 'is introducing smell technology to intelligent fashion.'[7] Her 'Re-cabling' fashion concept, developed during her PhD research, incorporating intelligent odour delivery systems consisting of miniature tubing and pumps into fabrics, suggests a more active approach to fashion design. Fragrances can be actively pulsed electronically through a cabling device system. The 'living dress' by Jenny Tillotson mimics the human senses, in particular the scent glands and introduces a concept of a sensitive Smart Second Skin for the Wellness Collection.[8]

172 A wearable badge triggered to release pheromones designed by Jenny Tillotson.

Sensory designer J. Tillotson, in collaboration with Charmed Technology, works with perfumers, chemists, medical technologists and nanotechnologists to pioneer 'electronic nose technology'.

'Since humans share many of their biological systems with other animal species [,] it seems logical that the sense of smell probably plays a much larger role than we commonly think in human social interactions, sexual attraction, sexual arousal, mating, bonding and parenting,' says Jenny Tillotson.9 In collaboration with Charmed Technologies she has designed 'PheroMate' 'to help wearers find their perfect partner through each other's scent (see Fig. 172). PheroMate can analyse the pheromones of people coming into contact with the wearer, and alert the wearer to those who match their pheromone profile'.[10] This system is based on 'electronic nose technology' which consists of sensor arrays coupled electronically to a sophisticated software system that provides pattern learning and pattern recognition techniques for identifying very small target odour signals. The electric nose was originally developed by scientists Dr. George Dodd and Prof. John Barker in the 1980s.[11]

As described in Chapter 10 there are commercially available textile products carrying microencapsulated odours which release a smell when triggered by a wearer or user. These types of olfactory systems contribute to a sensation of freshness, cleanness and wellbeing as well as mask unpleasant odours. There are other more sophisticated methods that, rather than masking disturbing smells, are actively tackling and absorbing them to secure an extra freshness in textiles or in interiors. They can also release controlled amounts of a selected aroma.

During my research I investigated the olfactory, filtering and curative potential of textiles for the design of polysensual and interactive textiles for the body and environment. The analogy used is that of skin as an immunological surveillance mechanism, a biochemical mechanism and the site for our biological odour production.

In this part, my technical textile experiments were concerned mainly with testing the selected olfactory, freshness and filtering technologies that I felt were appropriate for inclusion in the SKIN STORIES concept for textiles applications. I was searching for the most appropriate technical and aesthetic means of combining them with other textile technologies in order to produce functional second and third skin surfaces.

11.2.1 SCRATCH 'N SNIFF

Scratch 'n Sniff technology that consists of microencapsulated aromas, which get activated when mechanically triggered by scratching or rubbing, is not new (10.5.2). However, I decided to use this technology for my work, since from a designer's perspective - Scratch 'n Sniff combined together with 'touch formulated' thermochromic surfaces might create a perfect match inviting people to interact with textiles in new ways. They can explore not only their tactility and a visual representation of their bodily prints created by body heat, but also experience different scents which get activated on touching the textile surface introducing the third sensory aspect – smell. Additionally, scents can be colour coded as shown in Figure 173.

11.2.2 HEAT 'N SNIFF

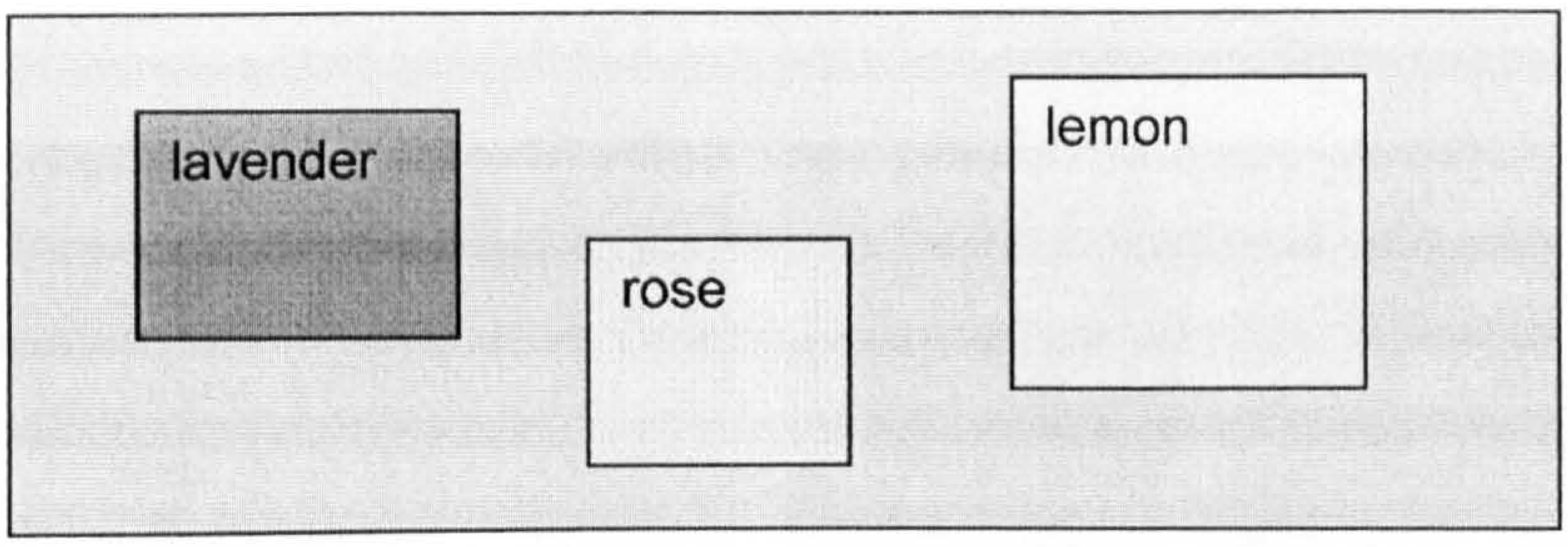
Another release-control method for aromas imbedded in polymer matrices is to stimulate them with heat. At a certain pre-designed temperature, the capsule's wall material starts to slightly change its substance by melting and delivers the core material scent. Upon decrease in temperature the capsule's wall material turns hard and no aroma release is possible. My idea was, and still is, to activate scents in textiles by warming certain areas of a fabric surface by applying an electric current. This system again refers back to our bodily mechanisms by mimicking the release of our biological odours in the skin when our sensory system receives certain stimuli. The technological process for triggering smell release is very similar to that used for the VERSICOLOUR system, as seen in Figures 174 and 175, only instead of a thermochromic layer a microencapsuled aromatic layer is applied. (See also Fig. 180, 181, 273). I refer to this system as HEAT 'N SNIFF.

A series of experiments encapsulating fragrances with the aim of producing printing ink with aromatic capsules for textiles that can be triggered by heat, were conducted at the Fraunhofer Institute for Applied Polymer Research in Berlin. Firstly, I was testing various possible concentration degrees of aromatic oils in wax matrices for the purposes of chemical microencapsulation. Secondly, various combinations of waxes with various melting points for the wall material were examined, as well as experiments undertaken in order to vary the thickness of the capsule shell for the best release of fragrances when heated. Thirdly, three types of microencapsulated aroma oils are possible to produce – powder, paste and dispersion and I had to find out which type is the most appropriate for mixing with a water-based printing binder (Magnaprint Binder FF).

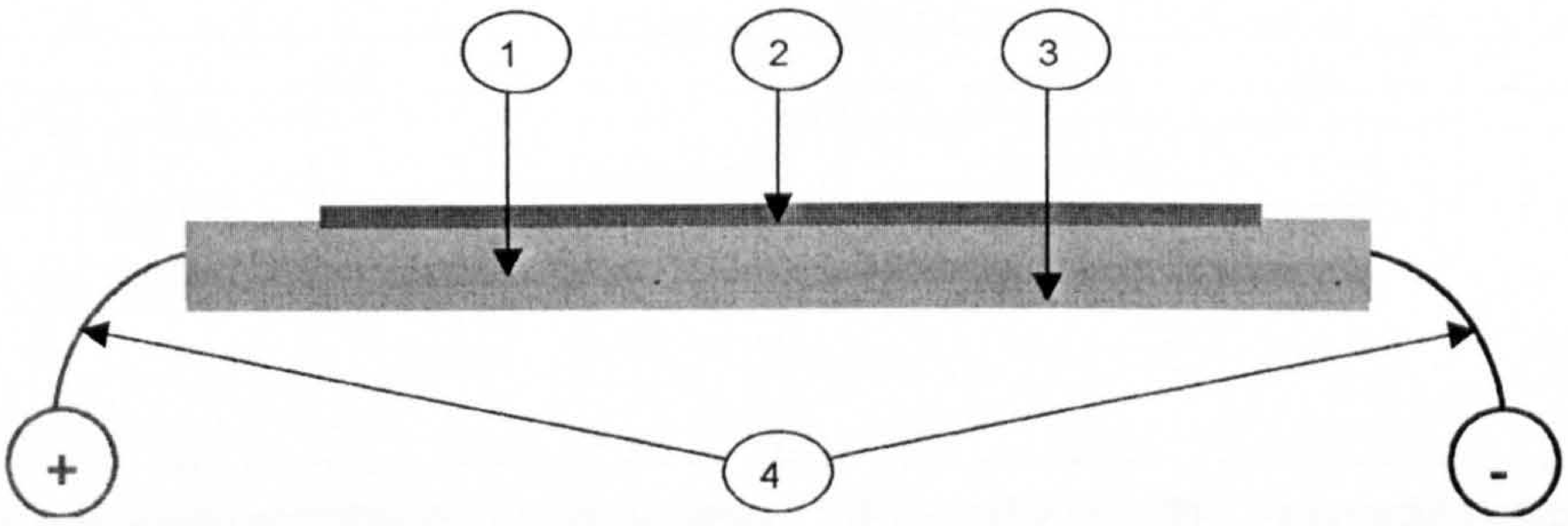
The basic recipe for encapsulation of aroma oils used was as follows:

500g	water
1,25ml	polyethylene glycol mw 300
42ml	2 N citric acid watery
42ml	modified partial with methanol etherified melanine resin, commercial PIAMID® M50 / M70
50g	wax 42 30 (melting point at 42 C°)
50g	aroma oil

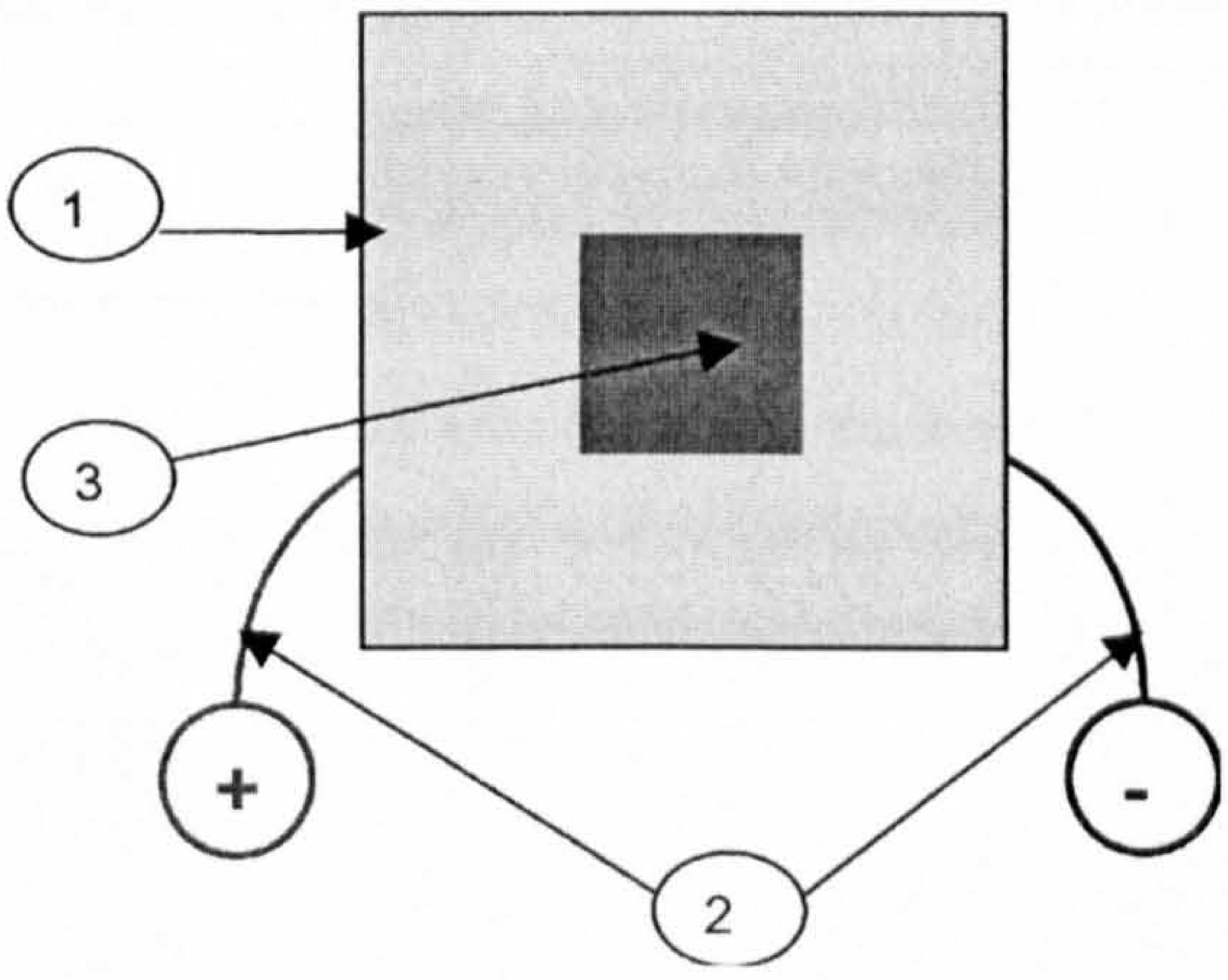
By the end of these chemical tests an aroma oil and wax mix in relation 1:2 was found to be the best for my purposes, as higher concentrations were releasing too strong odour and lower ones - too weak. Wax with a melting point at 42°C was used for the final samples of encapsulated fragrances so that the entire system can be easily activated by passing low voltage electric current through the conductive base material. Encapsulated aromas were mixed with the printing binder, usually in relation 2:8 (encapsulated aromas in the form of a slurry type paste : printing binder).



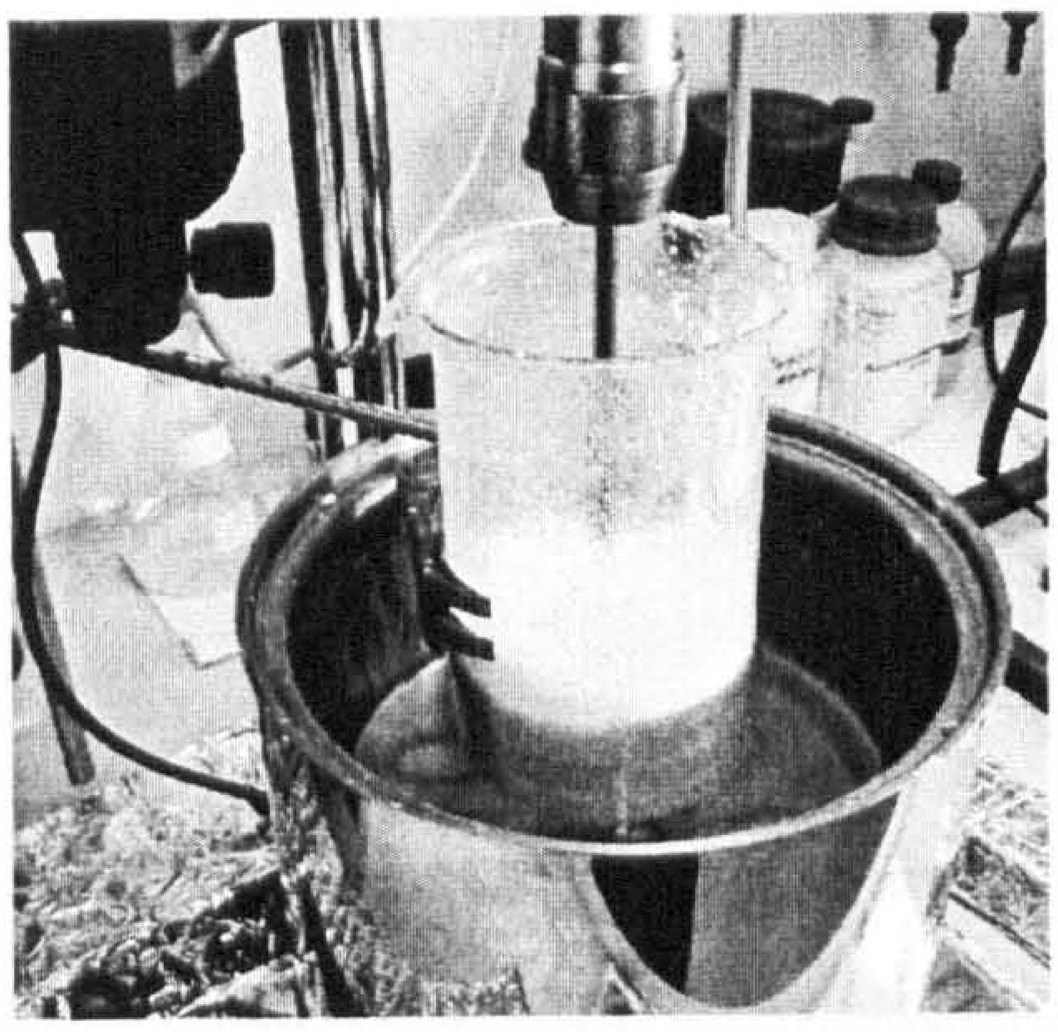
173 An example of a colour coded system for visual representation of different olfactory surfaces.

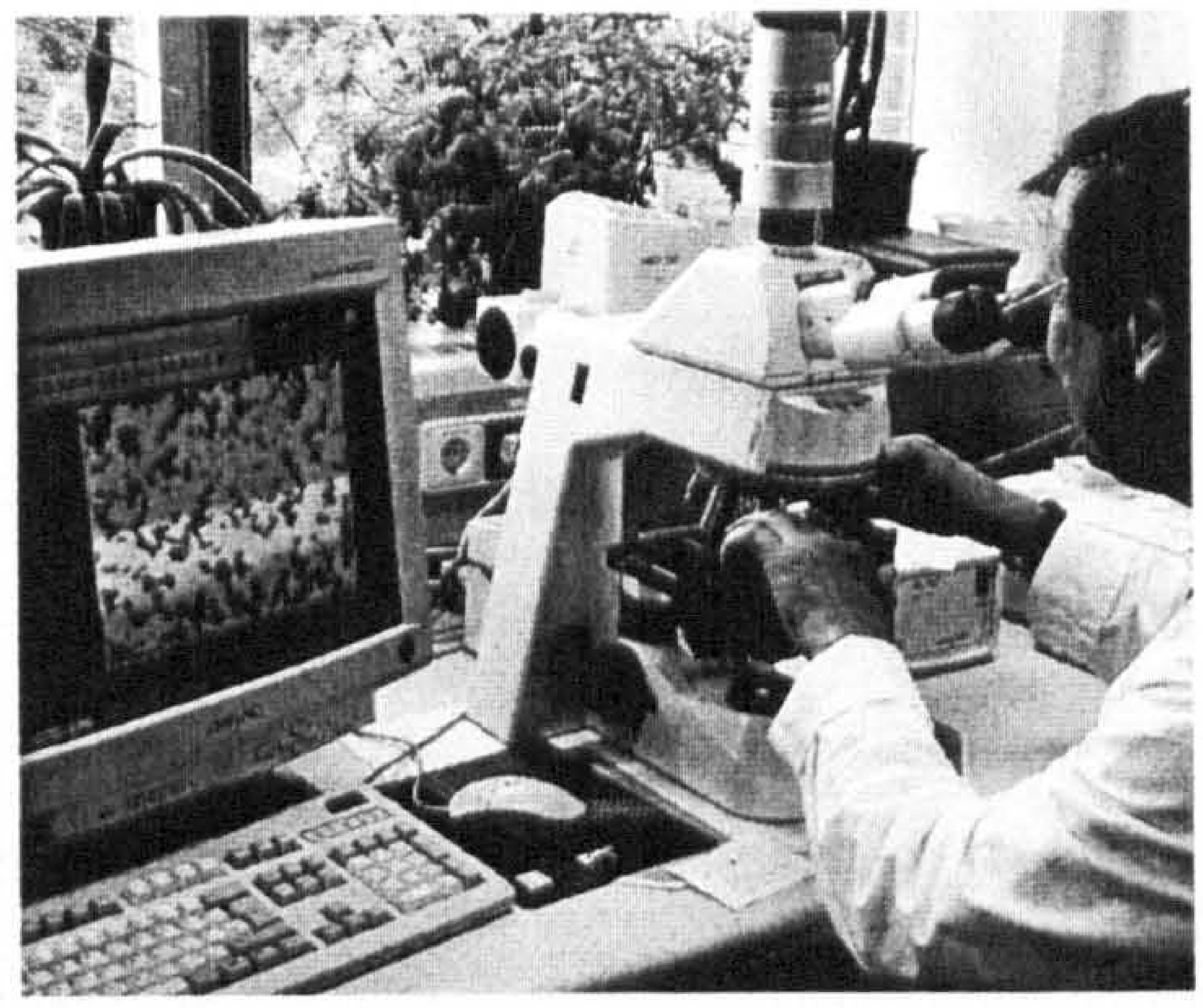


174 A cross section of a basic layered construction of Heat 'n Sniff fabric.
1 – the textile or other substrate, 2 – microencapsulated scented ink printed on the substrate, 3 – a layer of conductive ink which has high resistance printed on the same substrate, 4 – wires leading to the positive and negative terminals of a power supply.



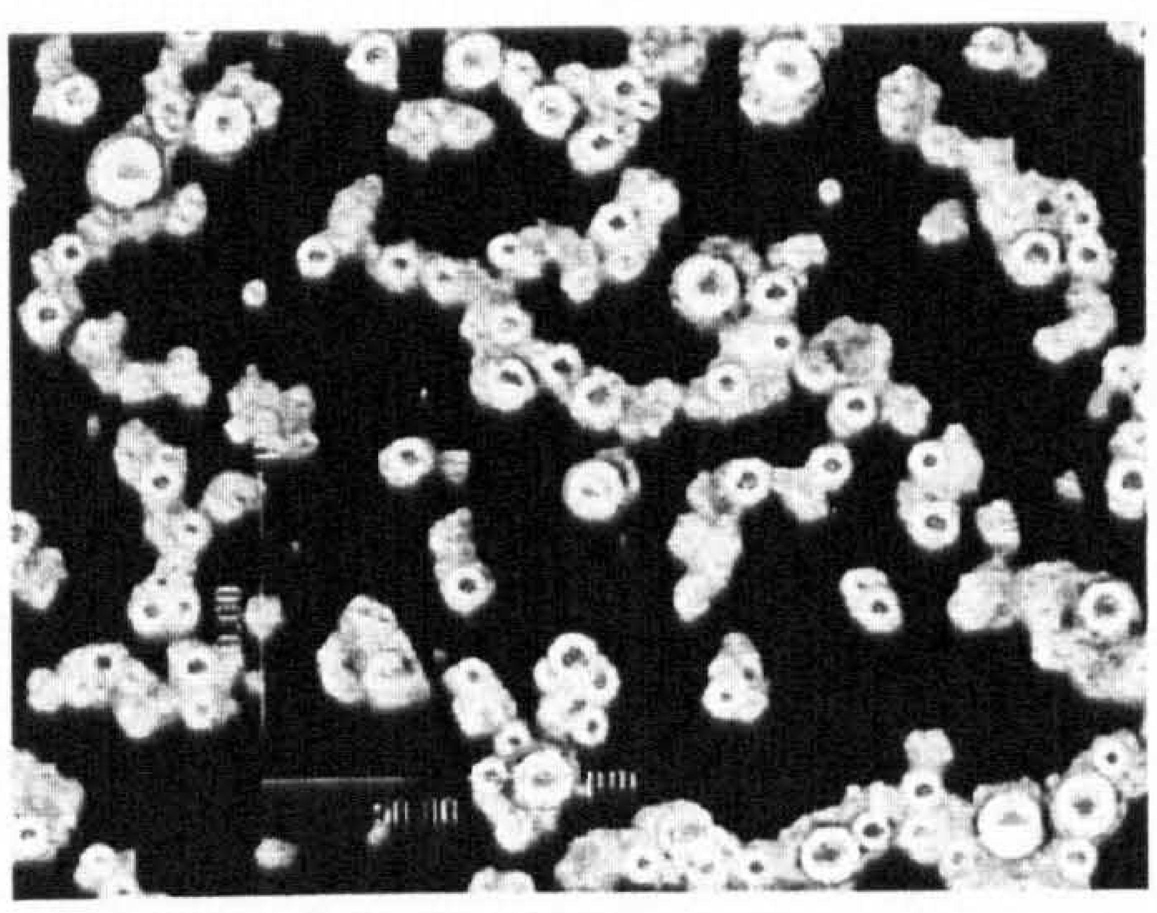
175 A frontal view of a basic layered construction of Heat 'n Sniff fabric.
1 – the textile or other substrate printed with microencapsulated aroma ink (central square); beneath – the same textile or other substrate coated with conductive ink, which has high resistance, 2 – wires leading to the positive and negative terminals of a power supply, 3 – Heat 'n Sniff effect – the release of aroma after a certain voltage and amperage has been passed through the conductive ink by heating up the substrate coated with aromatic ink.

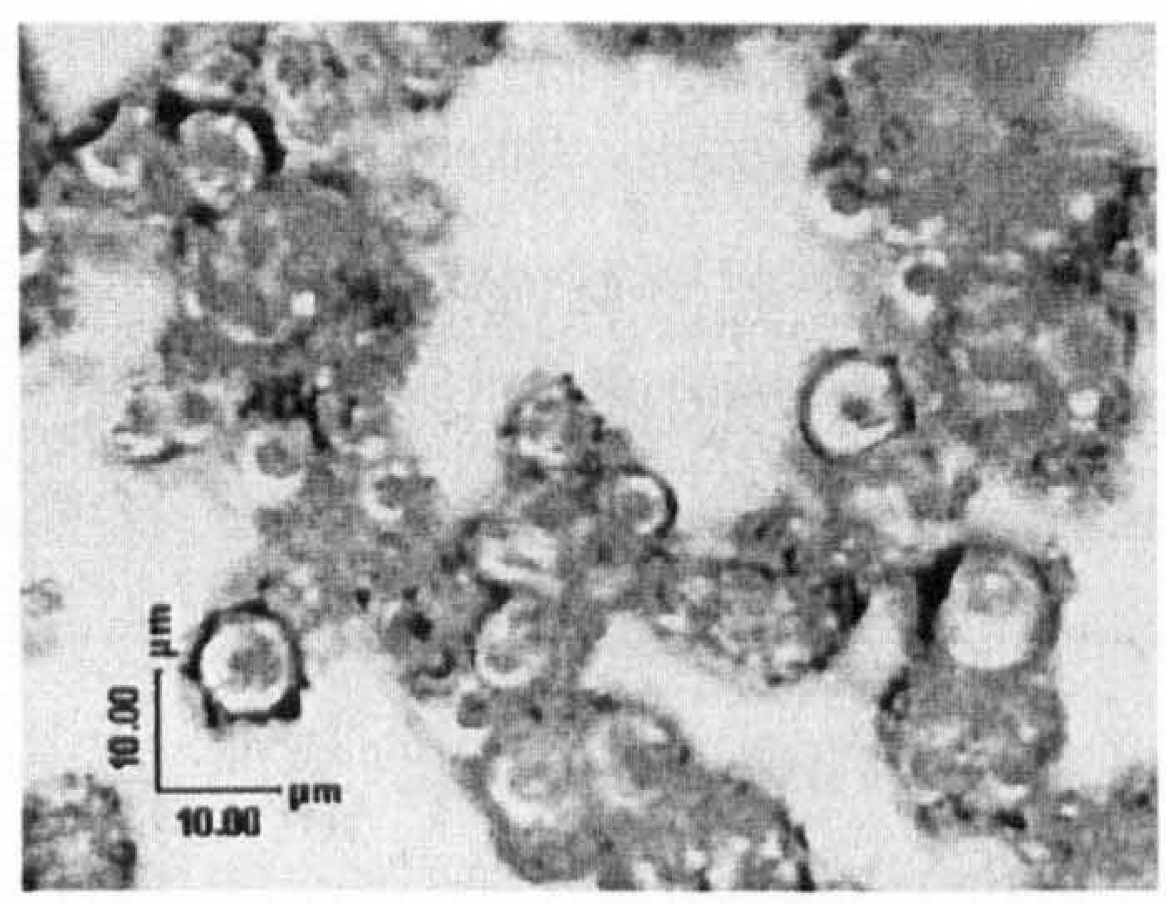




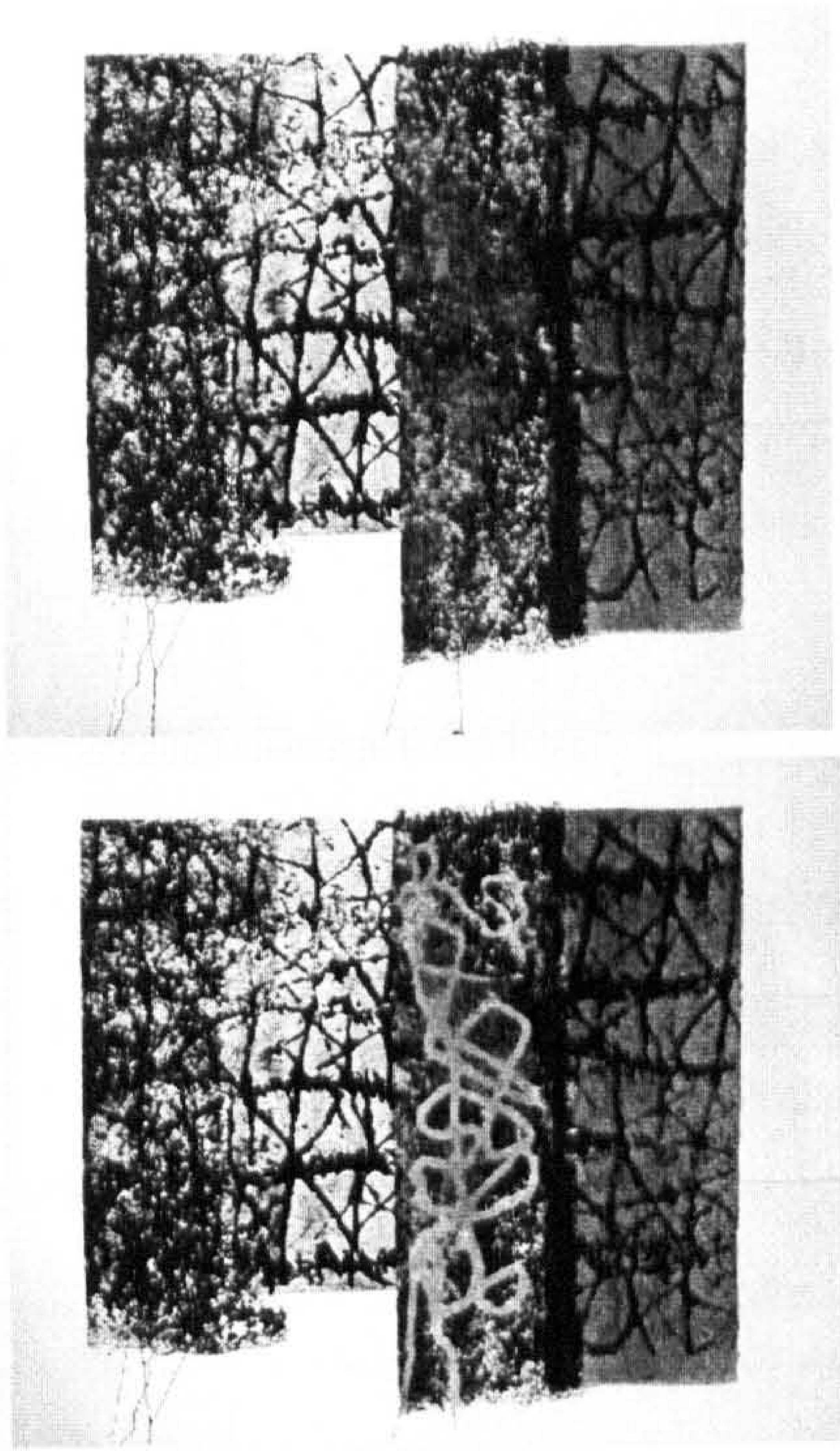
176 Encapsulation process

177 Testing the size and wall properties of microcapsules.



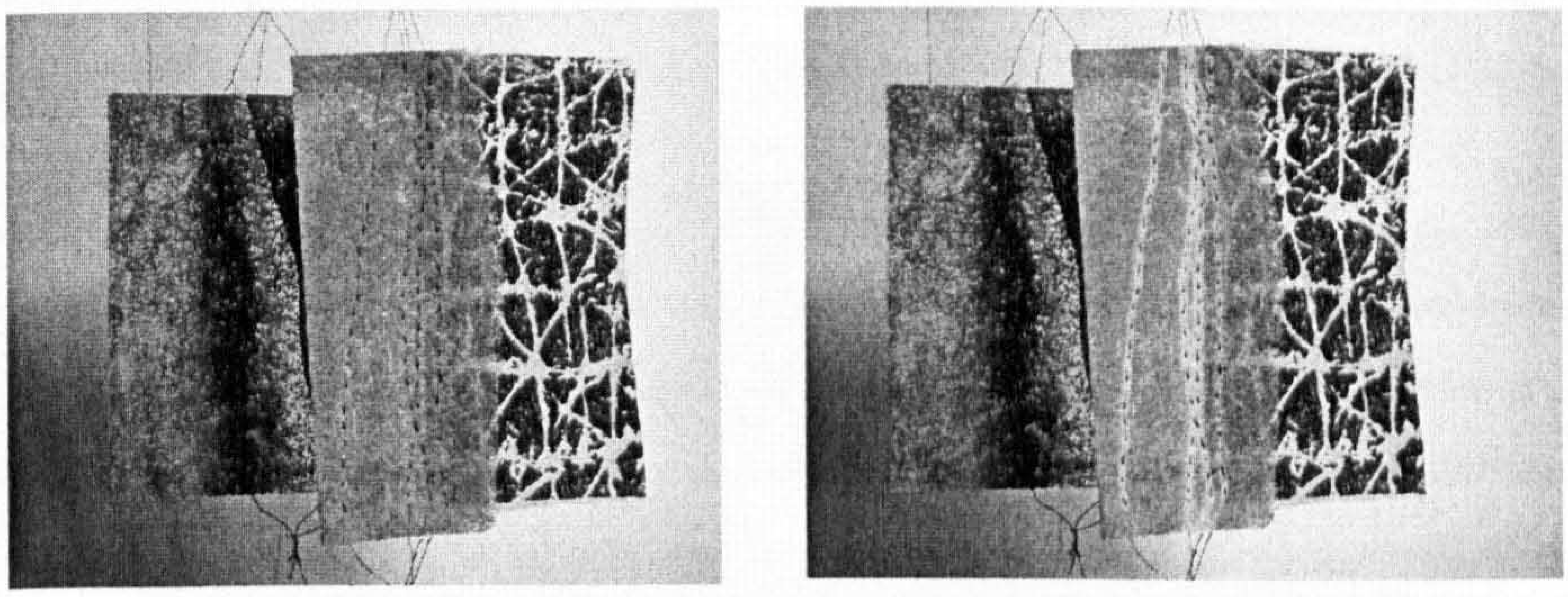


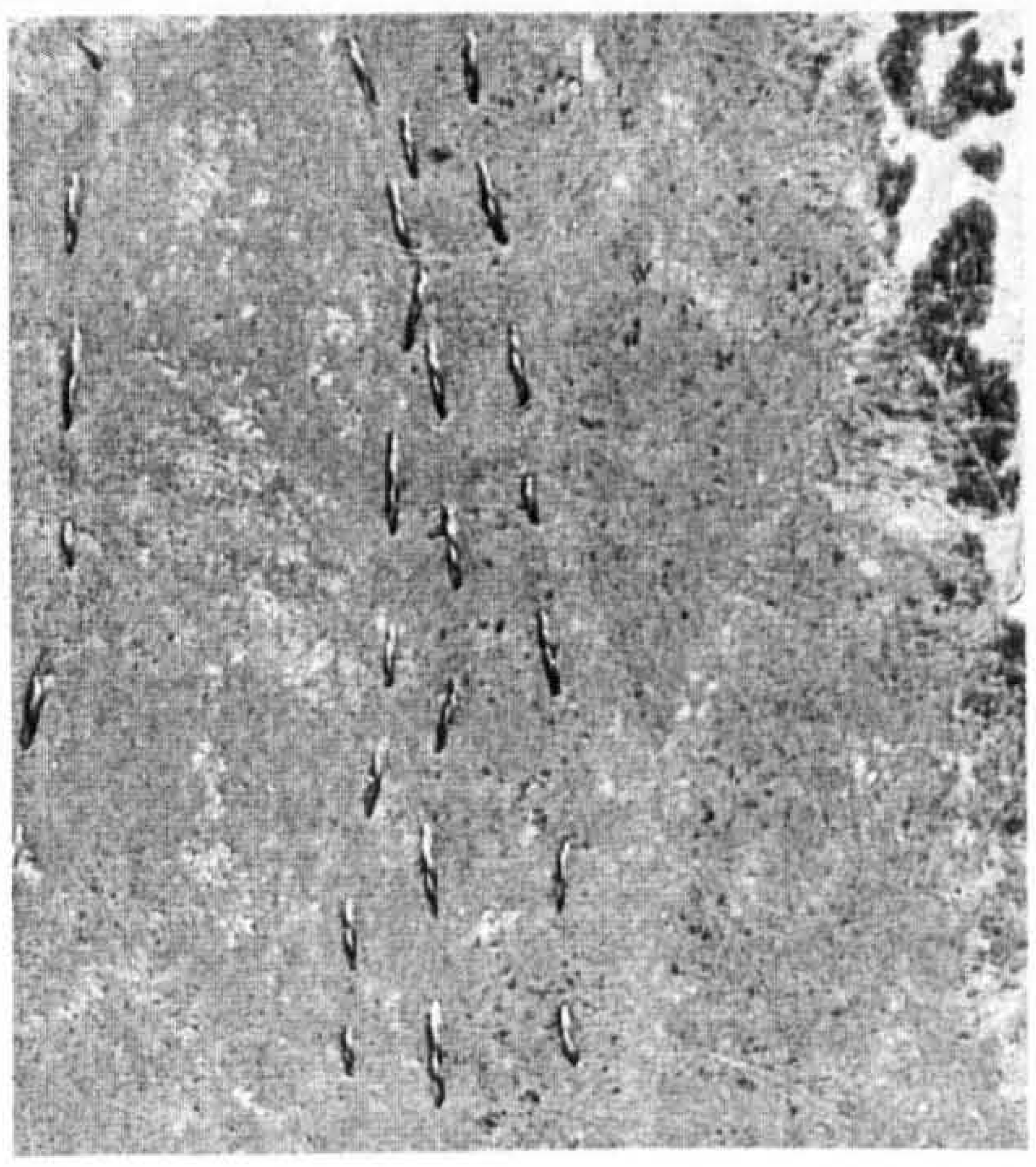
178, 179 Microcapsules.
Micrographs showing different aroma oils after encapsulation.



180 A, B

180 C





Working prototypes of the LIVING MEMBRANES.

180, 181 The operating principle of these prototypes is based on the:
a) colourchange properties of thermochromic inks, reacting to fluctuating heat, initiated by electric stimuli;
b) microencapsulation technology, which permits the incorporation of aromatic oils and fragrances in textile materials, to enhance the environment by releasing scent. Aromatic oils get activated in response to electric heat.

The aroma release mechanism and the colourchange effect are controllable.

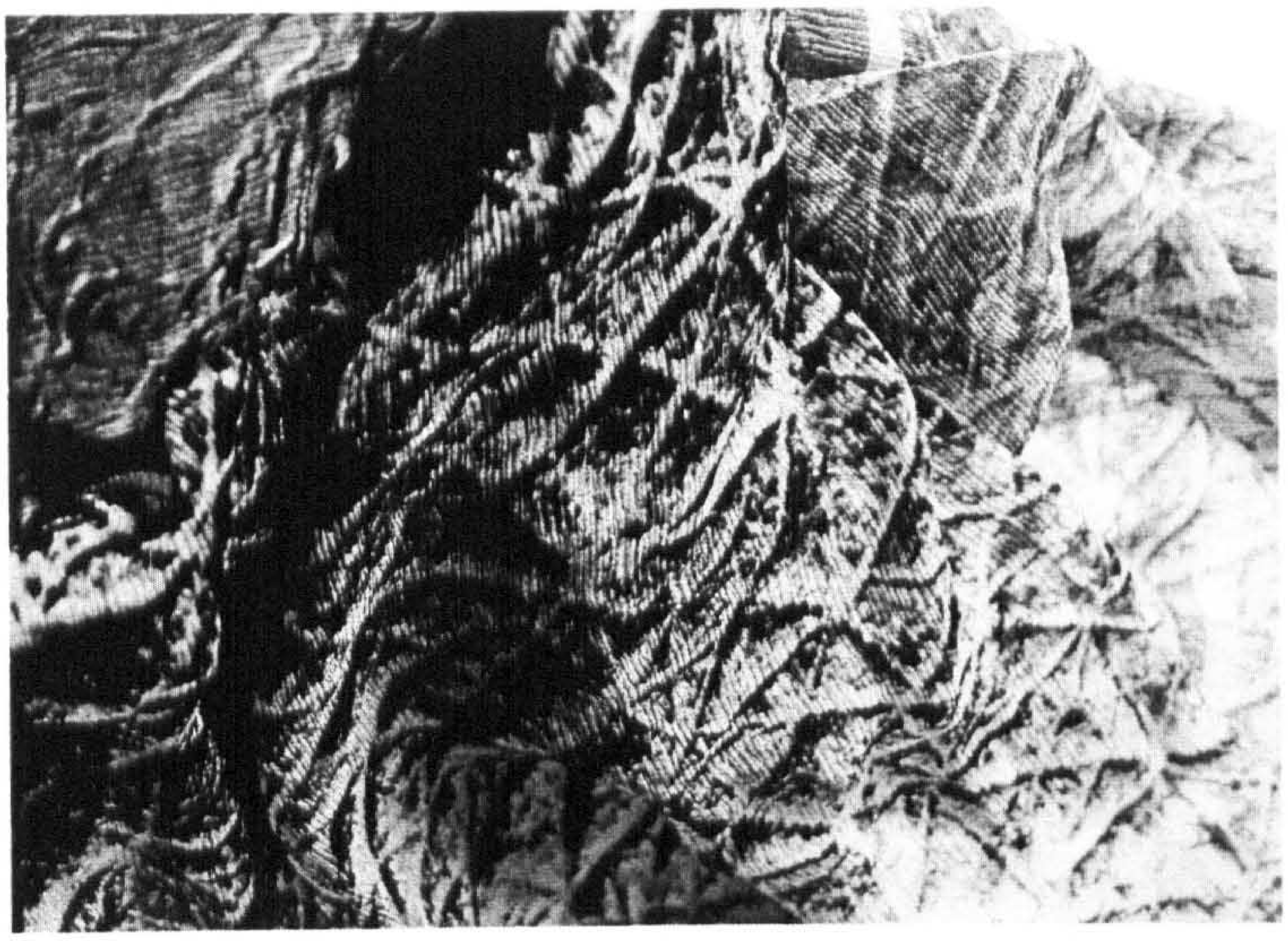
180 (A, B) Before and after the electric current is passed through the base fabric.

180 (C) Detail.

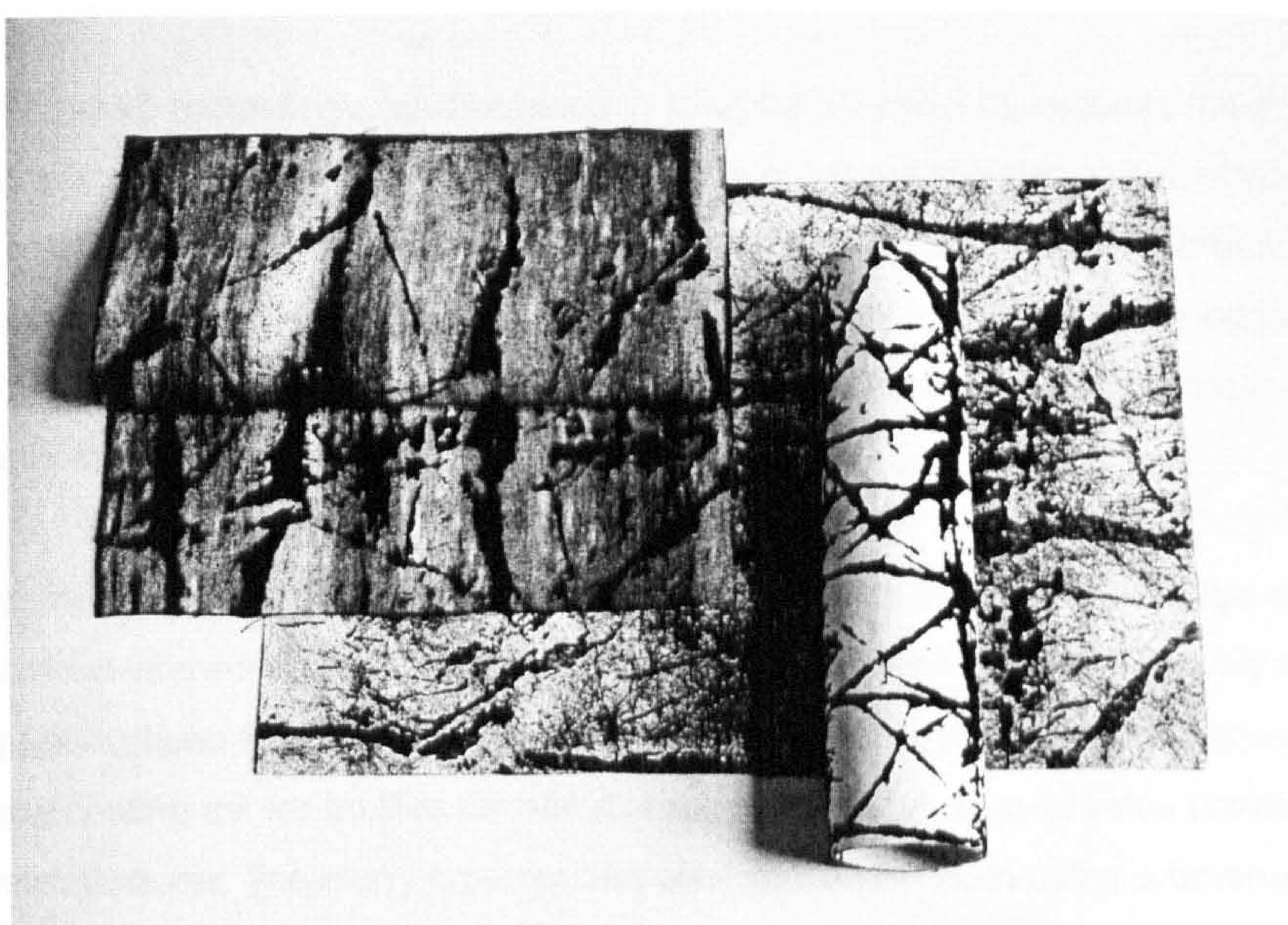
181 (A, B) Before and after the electric current is passed through the base fabric.

181 (C) A detail showing the embroidery using conductive yarn.

181 A, B, C



182 Textile sample treated with the BREEZE® anti-odour finish.



183 Textiles treated with the BaKaSave® anti-odour and anti-Sick Building Syndrome finish.

11.2.3 BREEZE® – FRESHNESS TECHNOLOGY

As described in Chapter 10 (10.5.3) compared with usual olfactory systems which simply mask bad smells, BREEZE® technology provides intelligent odour absorption by actively tackling all odours. I was particularly interested in this aspect because in our heavily aromatised environment, full of pollution, cigarette smoke, smells from the kitchen, various perfumes, and so on, it seems desirable that there is an escape for people who prefer the smell of 'clean air', at least in their homes.

Unfortunately, the BREEZE® anti-odour finish effect does not last for long as the molecules can only absorb a limited amount of smells, and, when full, have to be emptied by washing. Therefore this technology is not appropriate for interior textiles, but can be still used successfully for table cloths, napkins, bed linen and clothing – textile products, which are washed frequently. If the odour absorbing technology is coupled with the ROTTA-FRESH® system, an extra freshness function is achieved by releasing selected scent in doses as and when required. This helps to keep textiles fresh for longer periods of time and supports the people's need for comfort (see Fig. 182).

11.2.4 BAKASAVE® TECHNOLOGY FOR CLEANER AIR

The BaKaSave® technology, as discussed in Chapter 10 (10.5.4), reduces the so-called Sick Building Syndrome because it contains a special substance that absorbs harmful gases and bad odours in our environment by converting them into harmless substances like water (H2O) and carbon dioxide (CO2). In contrast to those odour absorbents, which bind smells for a short term like BREEZE®, BaKaSave® never reaches its saturation point.

My experiments with BaKaSave® were carried out in order to extend the range of functional and interactive fabrics for the textiles concept SKIN STORIES, mainly considering applications for interiors. The technology was employed using BaKaSave® slurry type coating ink for textiles as well as ready-coated fabric substrates provided by the manufacturer. The slurry type coating was applied on cloth using a brush and ready-coated fabric substrates were layered and bonded together with other designed 'skin' fabrics to enhance their functionality. The layered textiles refer to the multi-layered structure of skin where each layer performs a specific function working in synergy with the entire system (see Fig. 182).

11.2.5 SUMMARY

Different types of aroma-release, freshness and filtering textiles for a concept of 2nd and 3rd skin have been developed for this part of my research focussing on their functional, aesthetic and sensory qualities. These are textiles that hopefully will intelligently protect us from unpleasant or even unhealthy environments and contribute to our wellbeing by employing chemical mechanisms similar to that of our own skin. They function like our second and third epidermis, protecting and actively enhancing our physical and psychological health by improving our olfactory environments, and in this way they contribute to the overall philosophy of the interactive SKIN STORIES design concept.

I believe, we surely might benefit from having our olfactory environments designed to be 'odour positive', meaning that olfaction is used for the positive benefit of inhabitants. This could be done by generating appropriate odours at designated areas and at a desired time.

Both natural essential oils and specially designed fragrances can be applied to interact with our sensory worlds, depending on purpose and individual taste. Aromatherapy fragrances contribute to our physical health and sense of wellbeing while deodorising fragrances prevent the build-up of malodour during wear or use of textiles and keep them fresh when the textiles are not in use. Anti-bacterial and anti-microbial fragrances inhibit the growth of odour causing bacteria. By making olfactory environments 'odour neutral', odour absorbing systems and absorbents of harmful gases are actively preventing us from offensive olfactory experiences and illnesses that can be caused by unhealthy environments.

And finally – the HEAT 'N SNIFF system, developed during this research, allows activation of scents as and when needed, triggered by electric heat passing through a conductive fabric or other substrate. This establishes another epidermal analogy, with the skin as a carrier of electric messages through our nervous network, which in turn can change the colour of our skin, make us sweat and release more biological odours than usual. This system could find applications in fashion and in home textiles. The Heat 'n Sniff system works well together with the VERSICOLOUR and/or MULTICOLOUR CHROMIC DESIGN systems helping to create a polysensual and interactive environment.

11.3 FABRICS FOR PROTECTION AND COMFORT

Due to their physical properties, Phase Change Materials (PCM) are interesting as a source of heat storage (10.6). Originally developed for NASA, currently PCM are finding their applications in the active-wear clothing sector, where the constantly changing intensity of the body's activities leads to a constant charging and recharging of the PCM-microcapsules. They are used in the lining to equip coats and jackets with intelligent paraffin wax microcapsules that act as personal thermostats, keeping the body temperature constant while journeying through transitional environments. PCM are known under the trademarks Outlast® and ComforTemp®.

PCM can be incorporated into fibres, foams and fabrics. Nike has pioneered this fabric technology along with many other high-performance materials in their sportswear designs.[12] Now PCM are widely used in different active-wear concepts usually in combination with other technical textiles.

As identified earlier PCMs are carrying a huge potential for applications in home textiles and architecture, helping to save energy and to cultivate environmentally friendly environments due to their interactive nature. That is where both leading PCM producers, Outlast Technologies Inc and Schoeller Frisby Technologies AG, are seeing a large future market segment.[13] However, a lot of further research is needed to adapt this technology to much longer temperature change cycles typical of living environments, as opposed to the continually changing temperatures in the human body. I have employed the PCMs in my practice considering their technical and aesthetic potential for future applications in interiors.

During my research I have identified other high-performance textile materials for our protection. These protect us from electromagnetic rays, have anti-static properties or are equipped with anti-bacterial functions. Other textiles are concerned with skin-like coatings and laminates that provide excellent barrier characteristics and good respiratory properties. I have incorporated some of these in my SKIN STORIES concept.

11.3.1 THERMO-REGULATING TEXTILES :: EXPERIMENTS

For this part of my experiments, I explored the potential of textiles as latent heating systems to control room temperature, based on the analogy of skin being a thermo-regulator. As suggested earlier, the identified PCM technology seems to be the most appropriate one for active thermo-regulation systems in future interiors, despite its current technical problems. For technical and confidential reasons, it was not possible to arrange for small encapsulated Phase Change Material samples to be provided for my technical experiments. Instead, ready-made PCM fabrics such as polyester non-wovens and polyurethane foams manufactured by the company Outlast were therefore employed (Fig. 184).

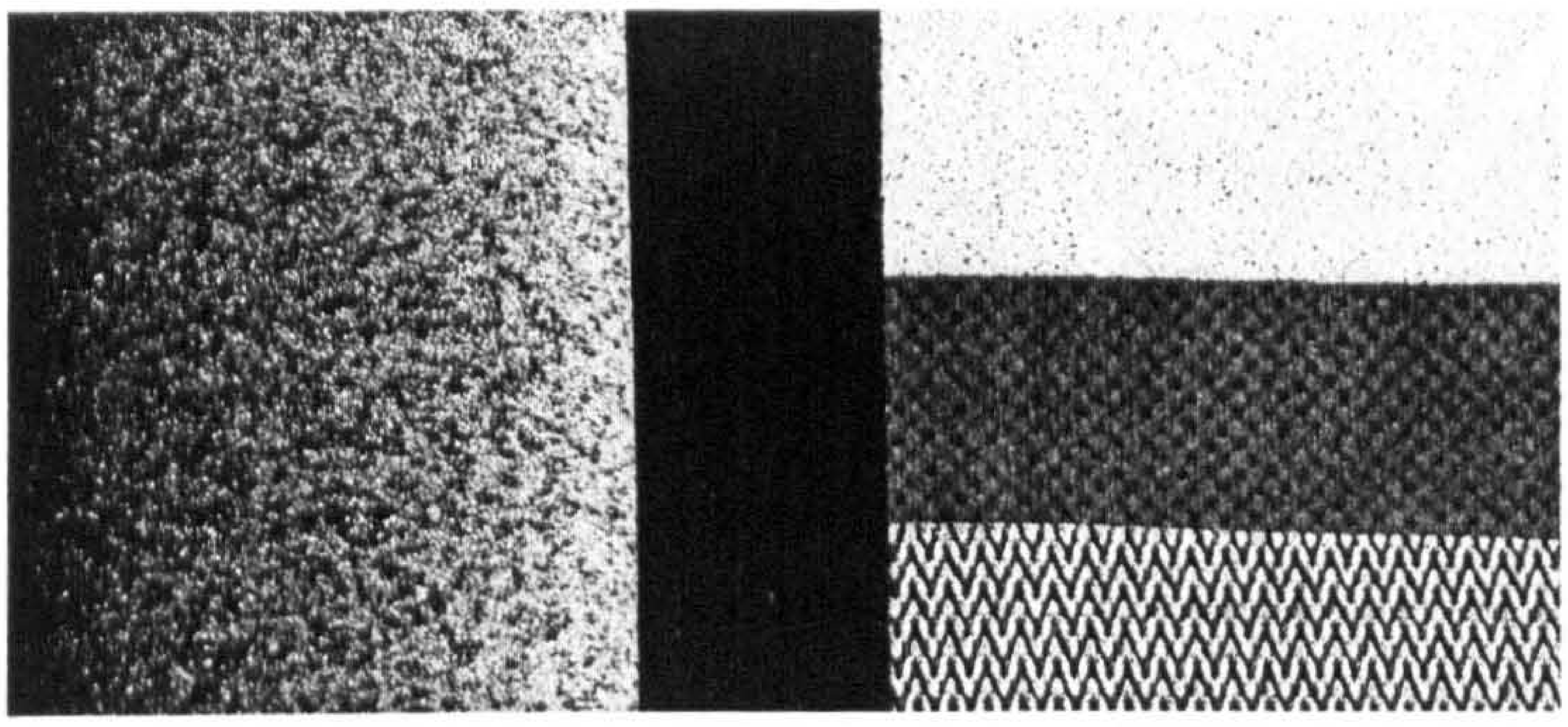
In order to advance their aesthetic, decorative and tactile qualities I bonded PCM fabrics with specially produced skin-like textile surfaces, which are described in Section 11.4. The new multi-layered fabric system has firstly, a designed surface, which is inspired by patterns of epidermis and secondly, a functional PCM 'dermis'. This construction makes the fabric look and behave like skin by performing a thermo-regulating function (Fig. 185).

PCM fabrics were also used in combination with 'touch sensitive' thermochromic ink technology and SCRATCH 'N SNIFF technology in order to develop functional and interactive wall coverings (see Touch Me Wallpaper, Section 12.3).

11.3.2 ANALOGY :: SKIN AS BARRIER MECHANISM AND PROTECTOR

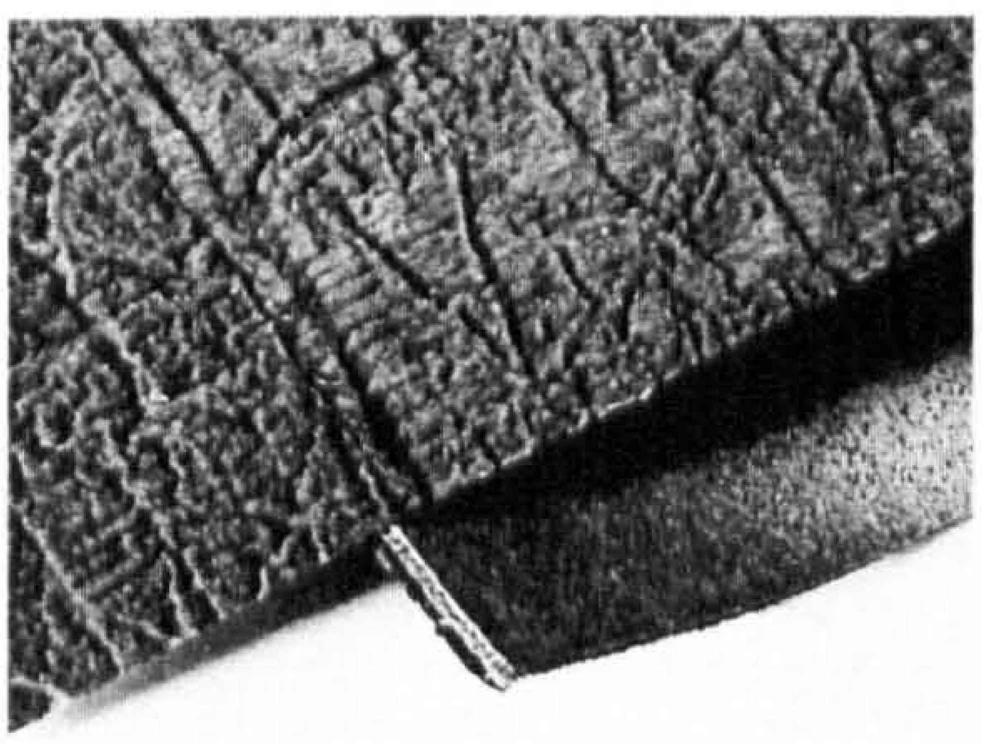
Under this section, ways of creating new and aesthetically appealing performance fabrics that provide electromagnetic shielding, anti-static properties and anti-bacterial functions were investigated. For this purpose, pure silver ink (10.7) was used to coat textile and other substrates in order to obtain the desired properties. As described earlier, silver is a natural anti-bacterial, anti-static and anti-electromagnetic substance. Ready-made silver-coated fabric Padycare® (10.7) was also used, bonded together with other textiles to create functional composite textile surfaces (Fig. 191,192).

In order to add other barrier properties to the new SKIN STORIES fabrics, coatings and laminates were applied on the fabric surface using thermo-adhesive films. Some of these transparent thermoplastic films have good respiratory properties and therefore can be used both for applications in interiors and for clothing to protect us from



184 Various PCMs produced by Outlast Technologies Inc.

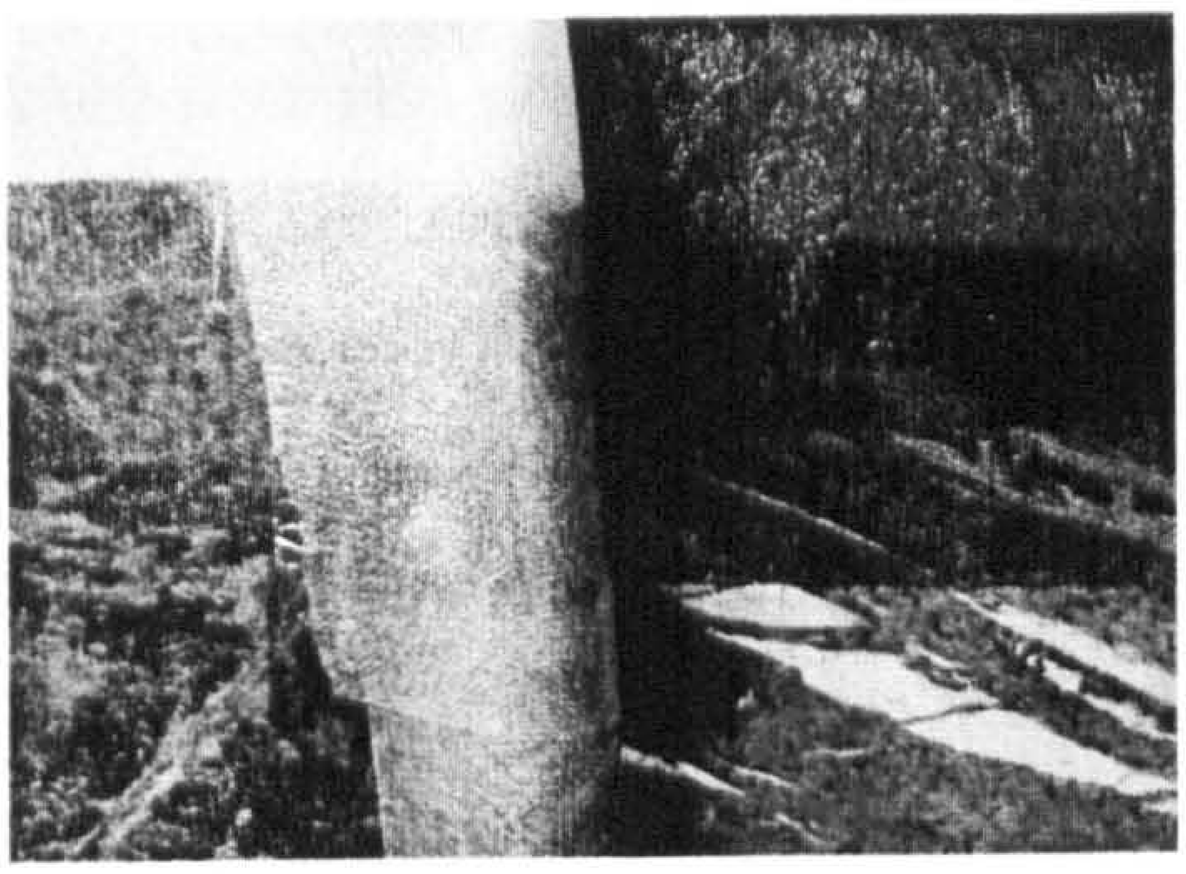
184

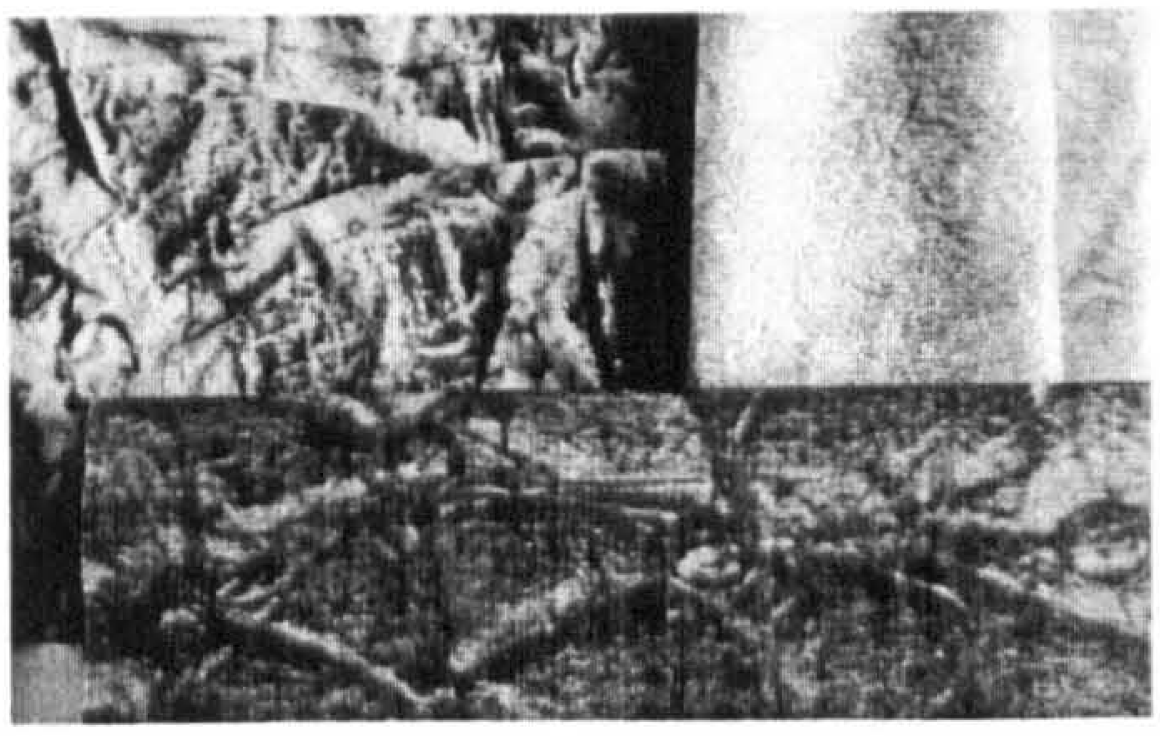


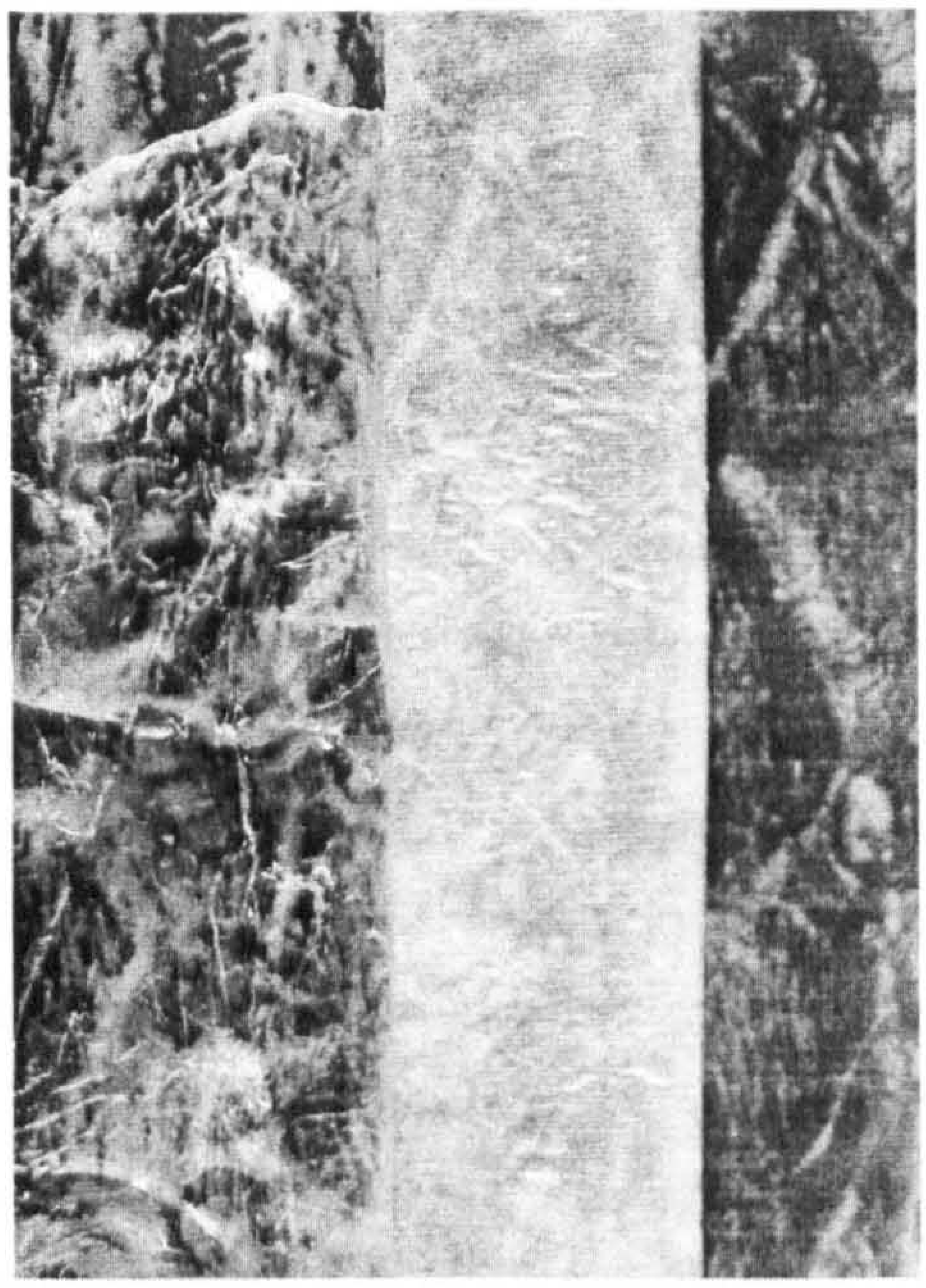
185 An image of the new multi-layered PCM fabric.

A SKIN STORIES design (dyed and screen printed crepe silk) with a PCM backing.

185







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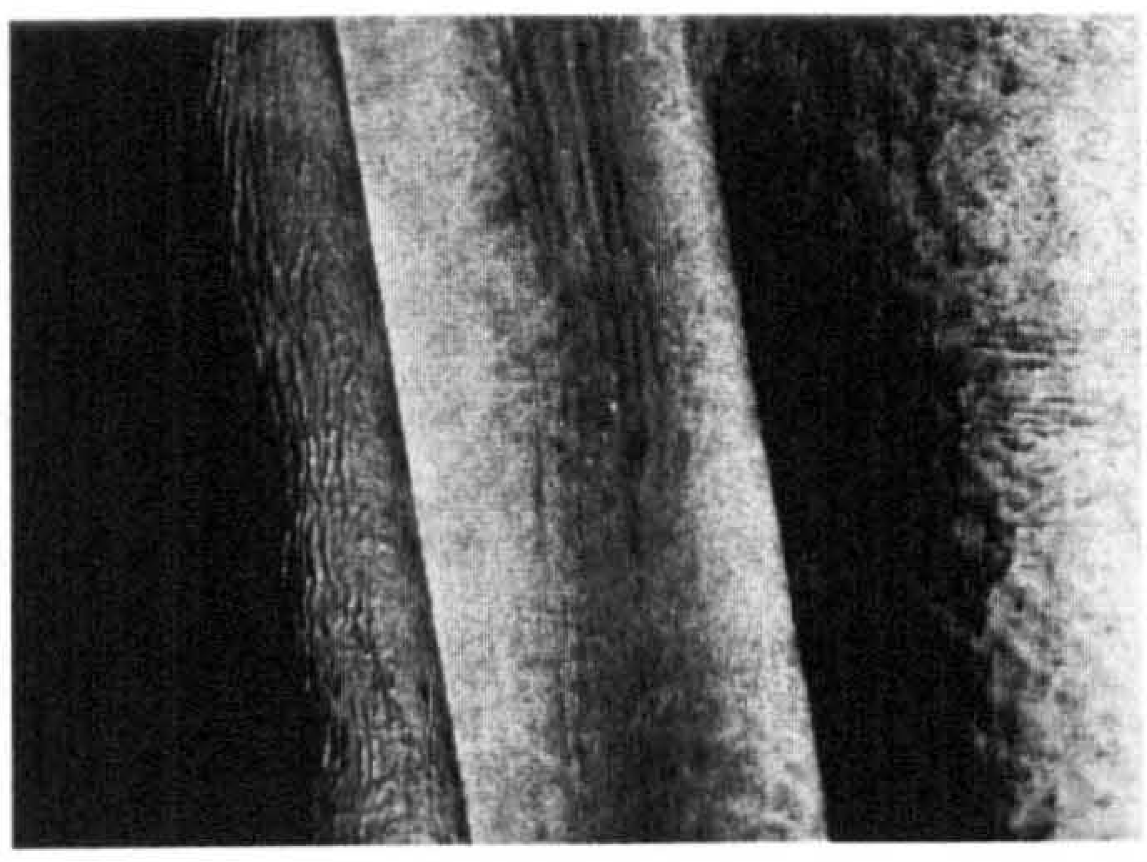
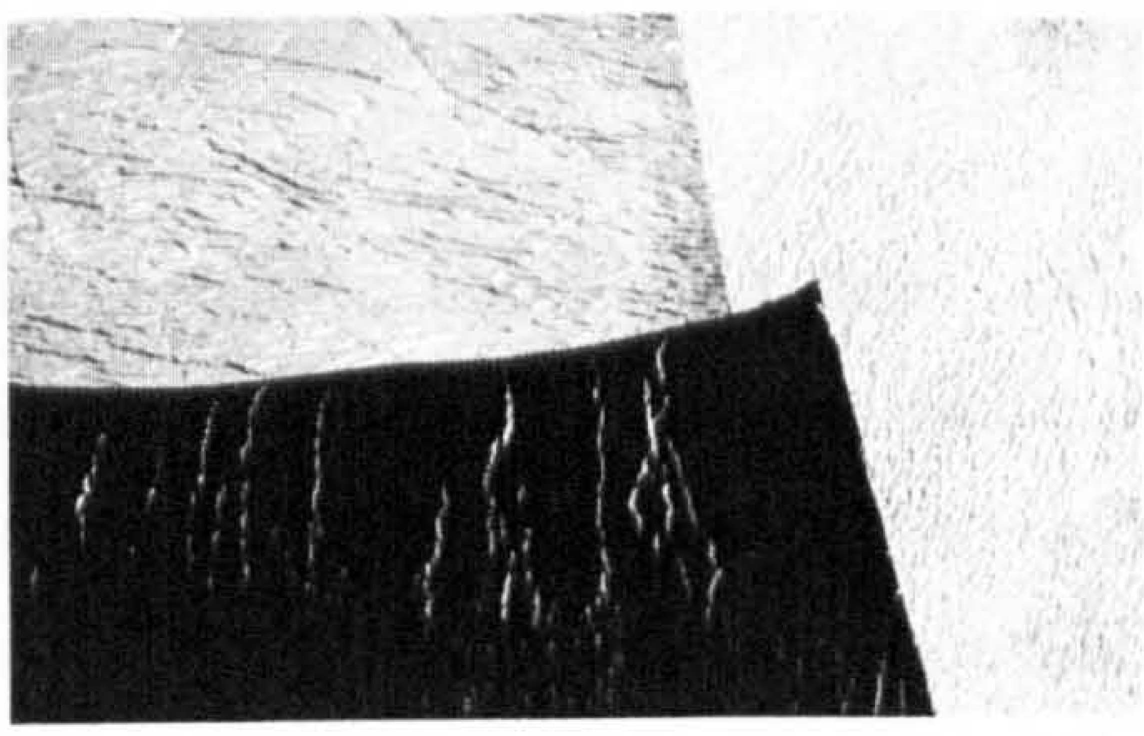




A selection of new SKIN STORIES performance fabric samples

186, 187, 188 Protective coatings and laminates using thermoplastic films and pre-printed ink jet foils on various base textile materials.

189 Textiles treated with the BaKaSave® anti-odour and anti-Sick Building Syndrome finish, as well as with waterproof protective coatings.

190 Double-sided textiles, treated with protective laminates.

191 Polyolefin coated with pure silver ink and carbon ink.

189, 190, 191

wet conditions, but also allowing our skin to breath. In some cases ink jet transfer foils were applied with pre-printed digitally manipulated patterns of skin surfaces. These films also provide a barrier function against abrasion and liquids, however they have not good respiratory properties (Fig. 186-188).

11.3.3 SUMMARY

As living environments tend to become more protective, responsive, active and interactive, issues such as sustainable and environmentally friendly design become more meaningful to society. PCM (Fig. 185), electromagnetic shielding, anti-static and anti-bacterial fabrics being active systems, are only a few of the many intelligent systems, which are likely to be integrated into our future living environments.

The result of my experiments contribute more tactile and aesthetic skin-like qualities to the technological aspects of these technical textiles for use in a functional fashion sector as our second skin, or in interiors (wall coverings, curtains, space dividers, coverings for chairs, couches or beds) – as our third skin. Due to the integration of thermochromic inks and aromatherapeutic scents into technical PCM fabrics, they achieve a new quality. For example, besides being a heat-controlling system for room temperature, they also provide an additional 'wellness' aspect by influencing our olfactory environments, or by entertaining us by changing colour when we touch them. Protective coatings and laminates, besides their functional barrier and respiratory qualities, can add a unique touch to technical or performance textiles improving their aesthetic and haptic qualities.

11.4 OTHER FUNCTIONAL AND DECORATIVE TEXTILES

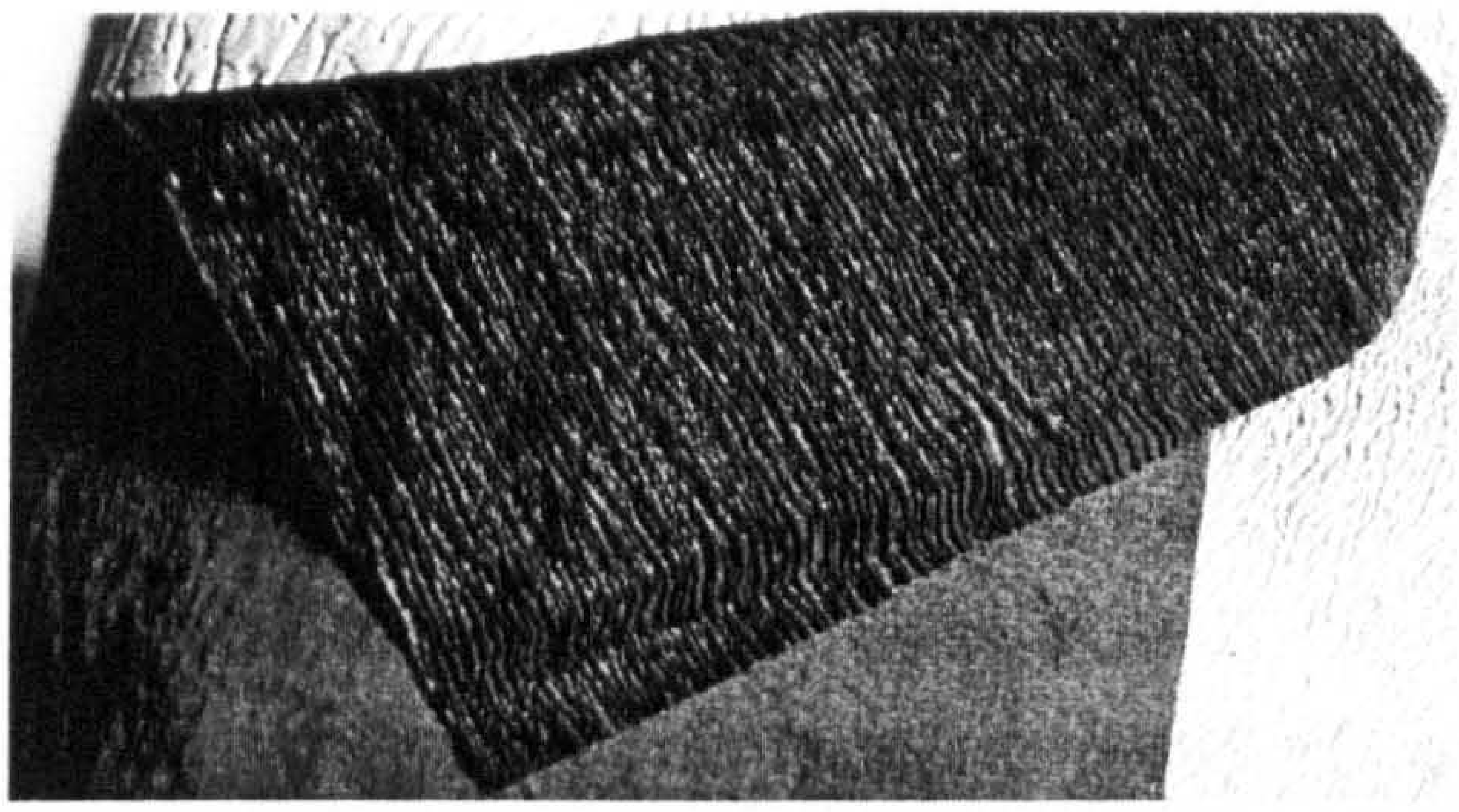
As identified in Chapter 10, apart from previously discussed technologies, many other textile materials and technologies have been tested for their inclusion in the SKIN STORIES collection. In addition to 'skin functions', which were the main enquiry for my experiments described above, aspects such as 'skin topography' and 'skin architecture' were explored with an aim to bring all the research discoveries together in a 'responsive and interactive skin technology' concept. My experiments in the textile studio, as outlined below, were based on the theoretical information gathered and the scientific images taken of skin structures collated during earlier stages of my research. For the relevant fabric samples, please refer to the Textiles File.

11.4.1 SKIN TOPOGRAPHY - SURFACES AND PATTERNS

My visual investigations of the skin tissue through microscope have served as an essential source of understanding the physical characteristics of the epidermis and how these aspects can be interpreted in my design practice. By using this method I was able to establish the aesthetic language for my textile collection, referring to skin's magnified landscapes, colours, patterns and surface configurations. In order to translate these qualities into textiles terms various textile technologies were employed: layering, coating, bonding, dyeing, pigment screen printing, discharge printing, heat transfer printing, black and white photographic technology, digital printing, moulding and others. Various surface effects were created using transfer foils, latex, silicone, adhesive webs, fluorescent pigments, photoluminescent and thermochromic inks, puff pigments, metallic foils and flock transfers (Chapter 10).

Different types of spunlaid nonwovens were used as base materials because of their structural similarities with the three-dimensional collagen-elastin structure of skin (Fig. 193,194). These polyester and polyamide nonwovens were manipulated using the technologies mentioned above. Woven cottons, silks and nylons were also used (10.1).

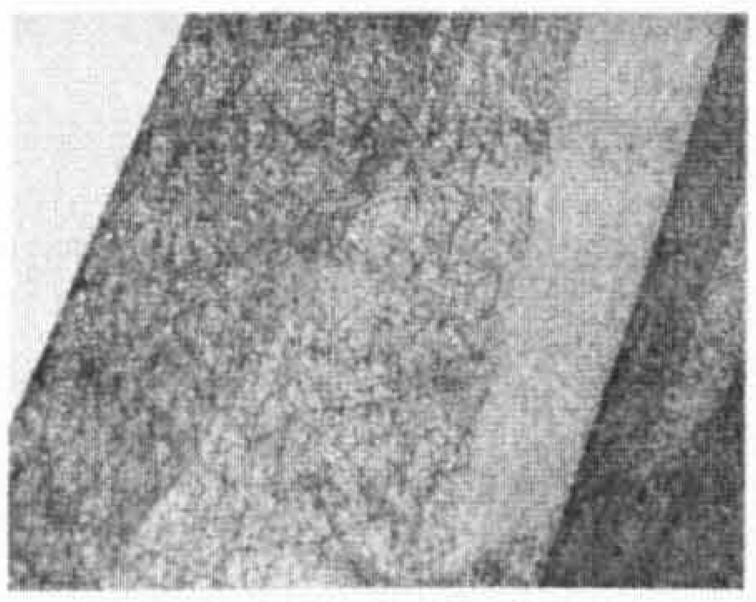
The information derived from the scientific images of the skin provided a source for development of the final print compositions. The selection of the collected visual information was digitally manipulated in order to form textile patterns for various printing techniques. The method of digital segmentation or filtering of the skin patterns used in my work relates to the scientific 'thresholding' method - the rendering and filtering of initial images obtained from skin replicas used in dermatology to detect the development of furrows (08.3). Using this method creatively, final print patterns for screen printing were developed by filtering out all middle tones, leaving patterns made from shadows and highlights only (Fig. 195-197).



192 SKIN STORIES design.

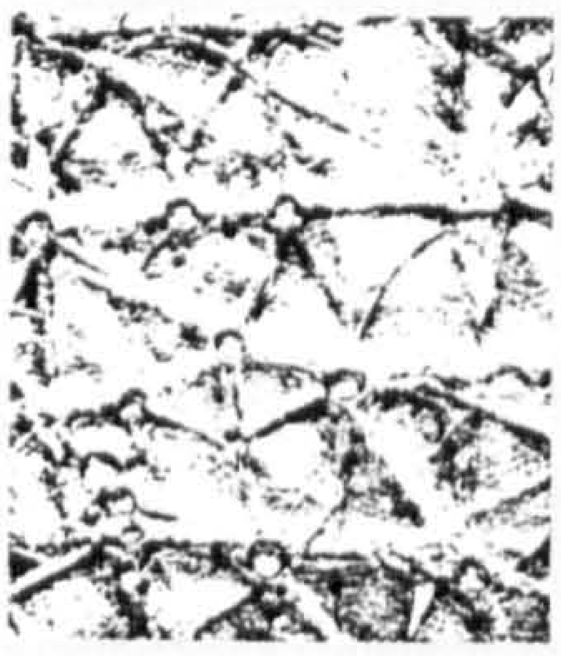
Dyed and discharge printed crepe silk bonded together with a silver-coated Padycare® fabric.

192



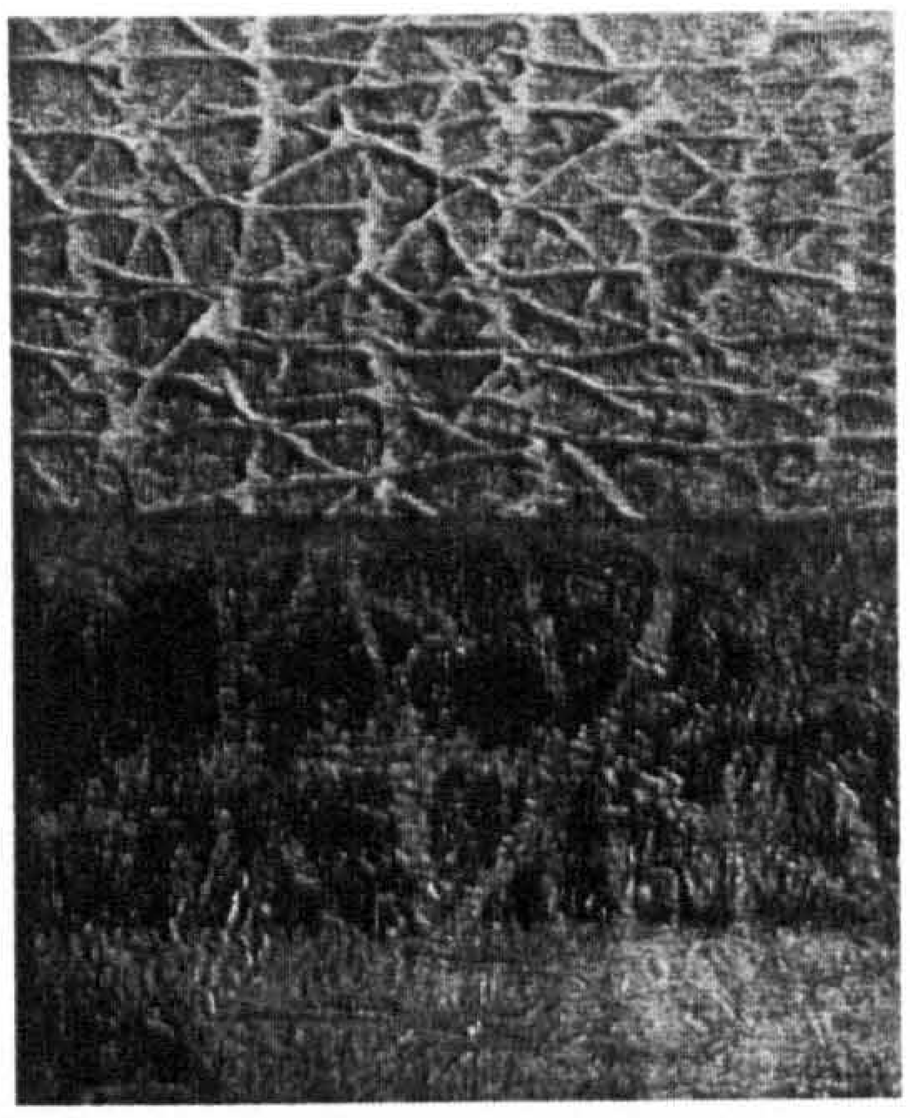
193, 194 Two different types of spunlaid non-vowens were used as base materials.

193, 194

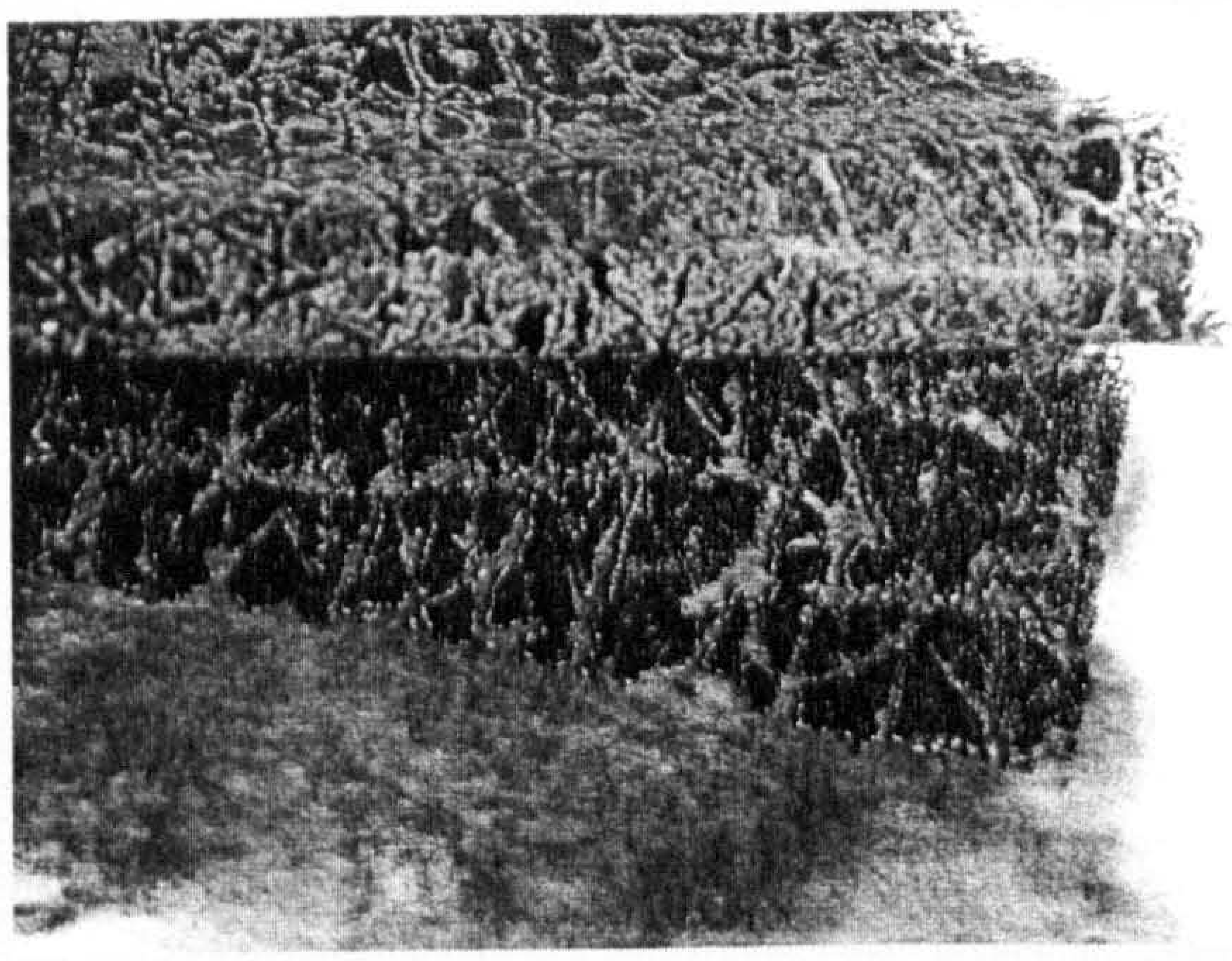


195, 196, 197 Print patterns obtained from skin replicas using thresholding method.

198 Discharge print on cotton.



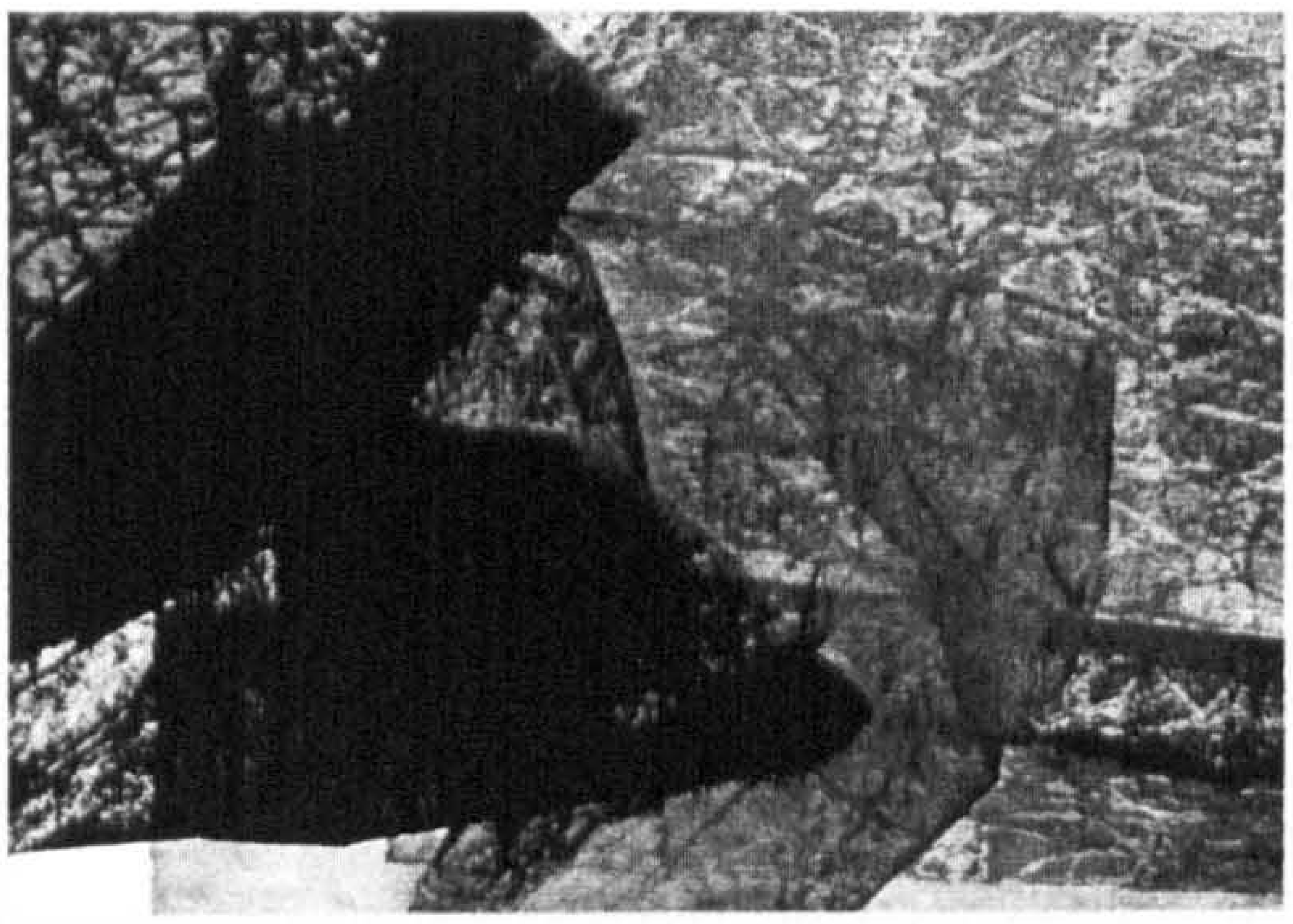
199 Puff print on nylon and fluorescent pigment print on polyester fleece that was latter laminated.



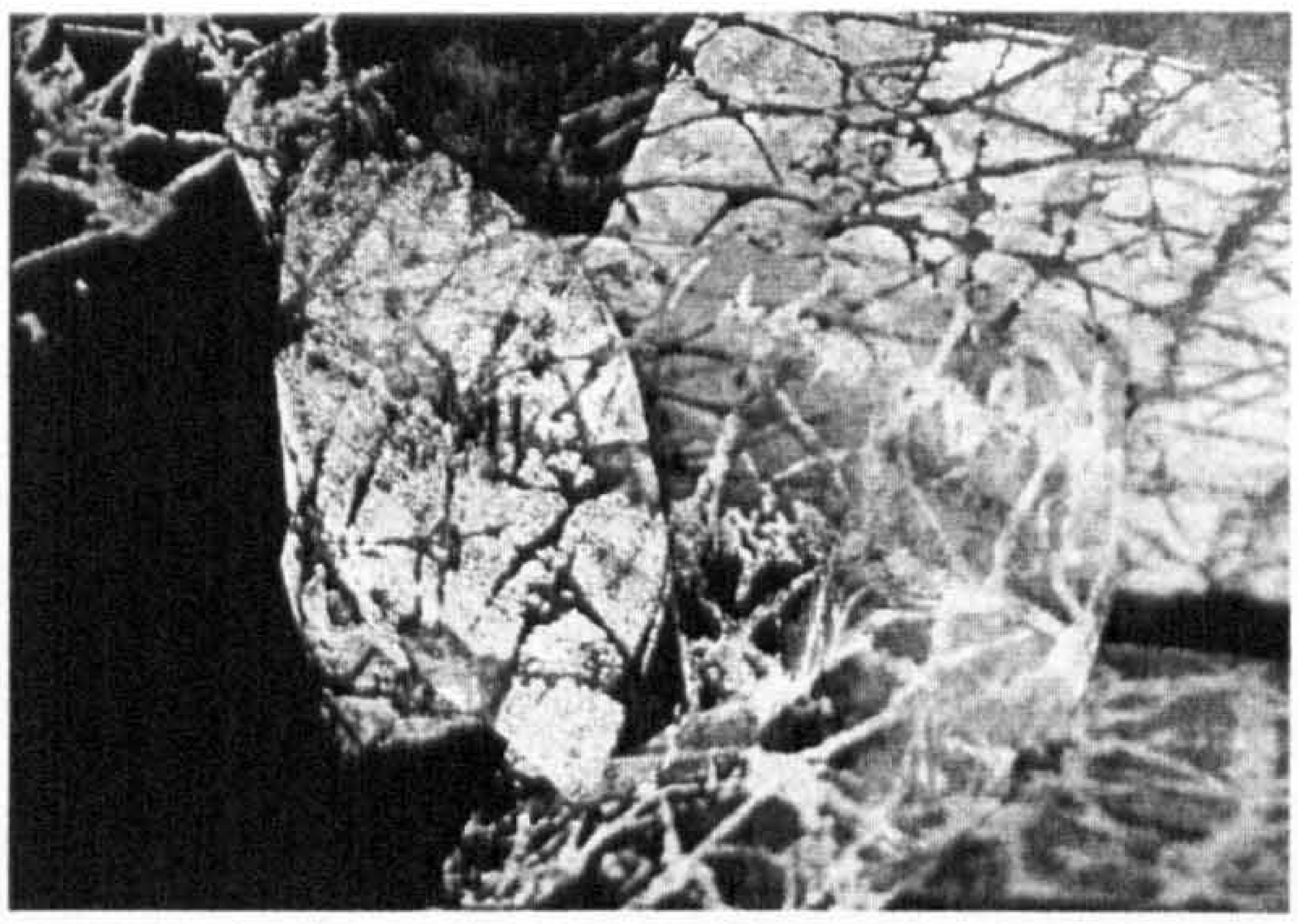
200 Puff print on polyester fleece.

201, 202 Discharge prints on crepe silk.

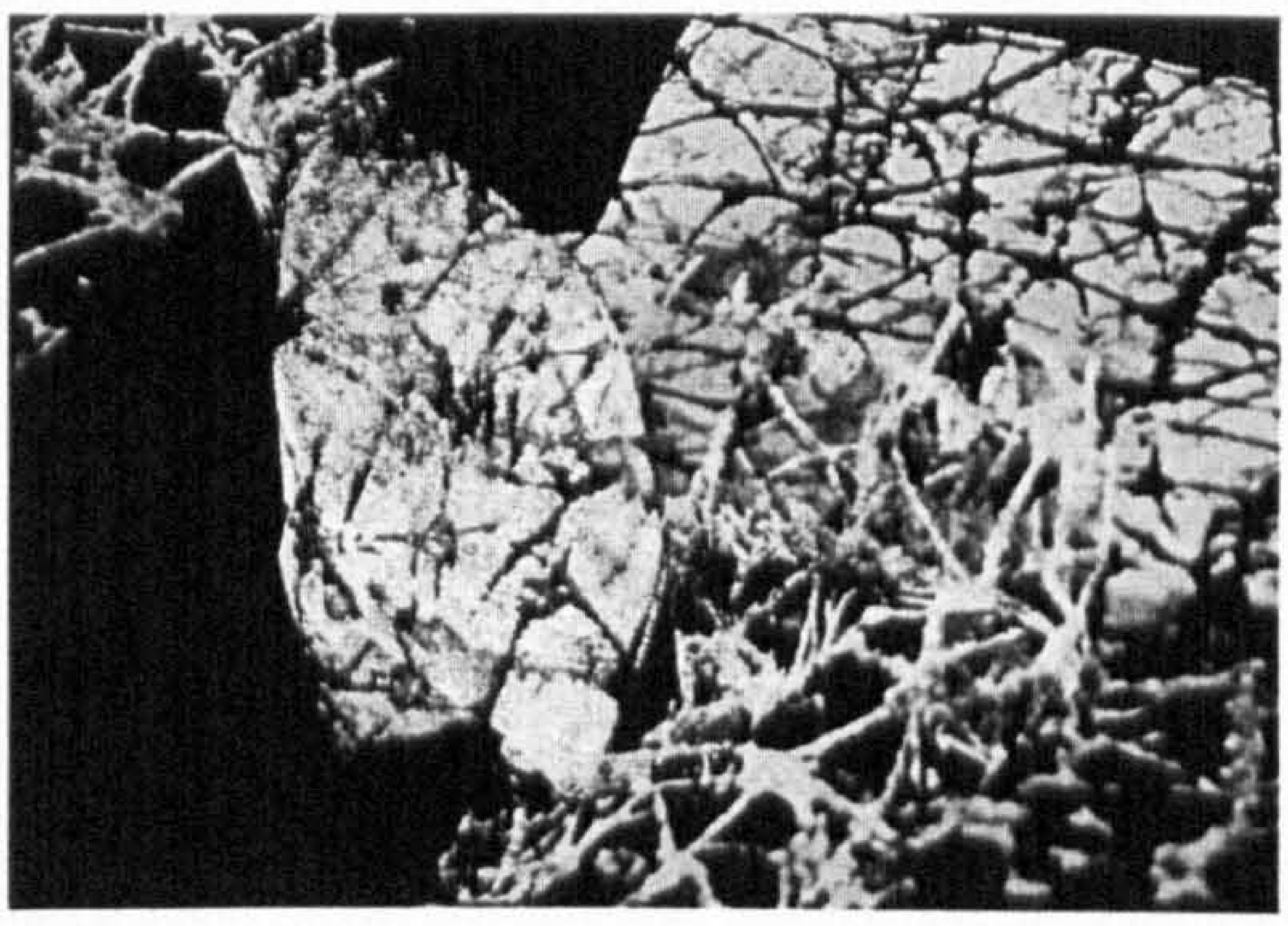
198, 199, 200, 201, 202 Resulting textile samples.
Screen print patterns are obtained from skin replicas using skeletonization method.
Puff pigment, discharge print, fluorescent pigments.



203 (A) Skin prints using fluorescent pigments.

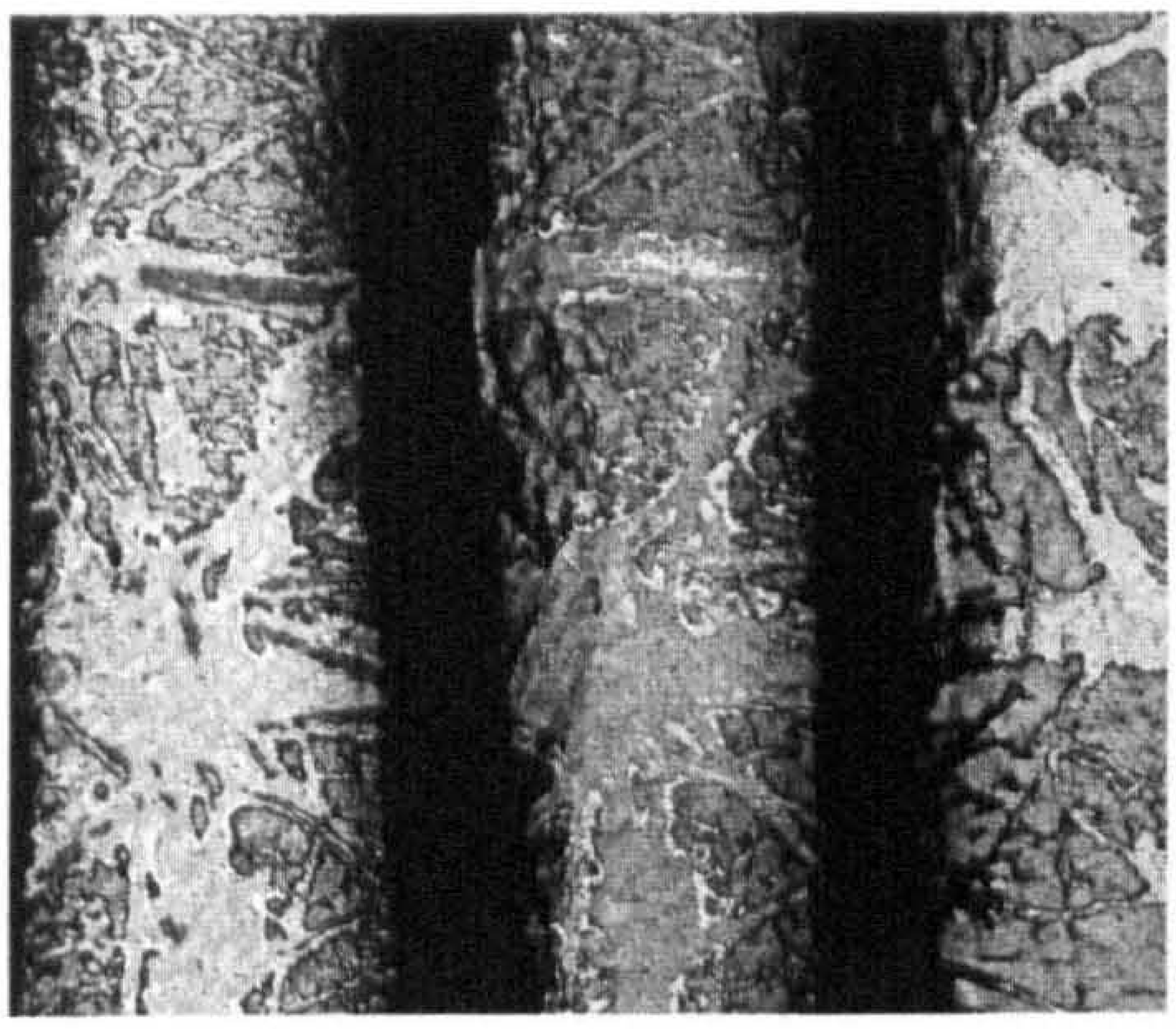
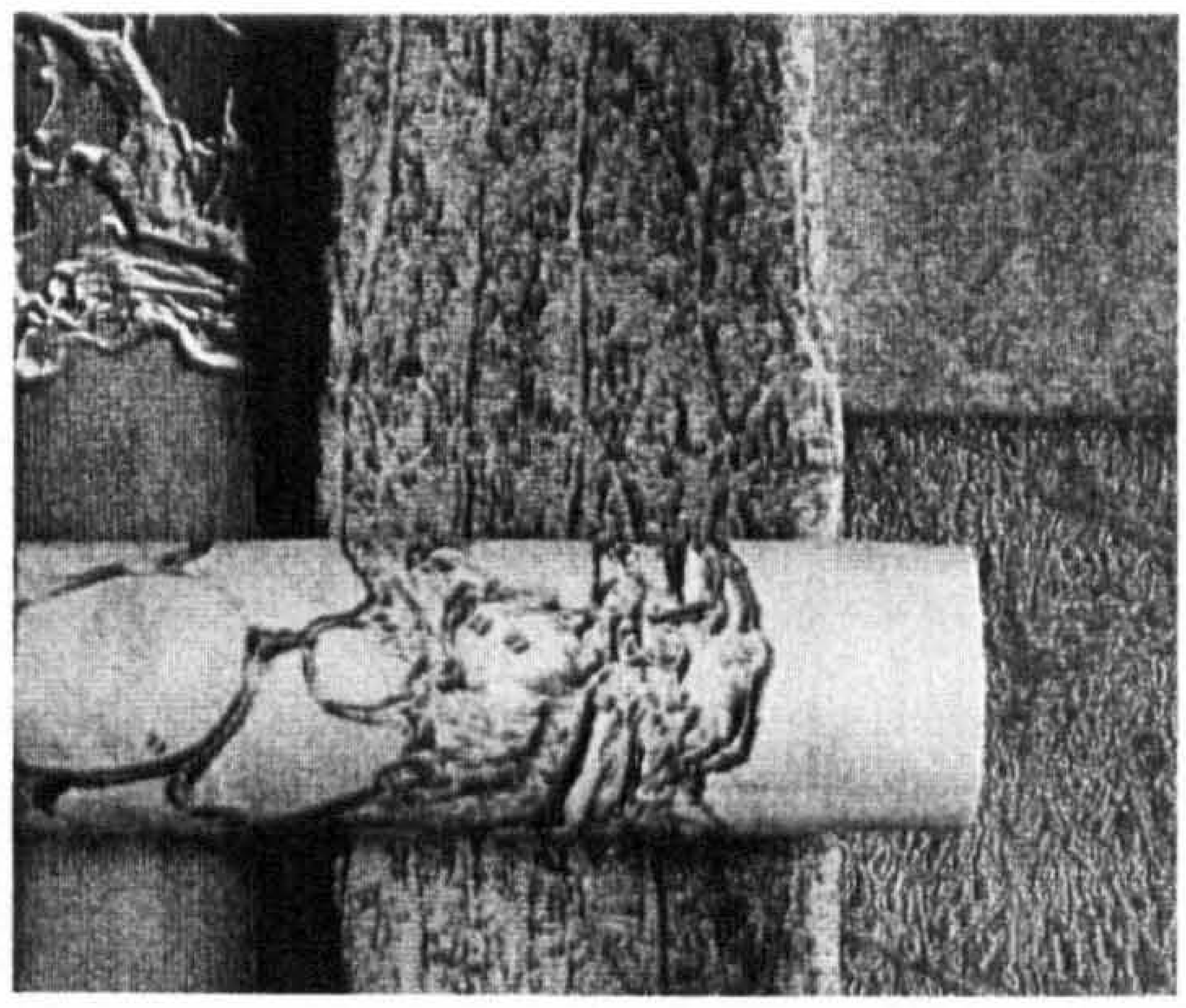


203 (B) Skin prints using fluorescent pigments.



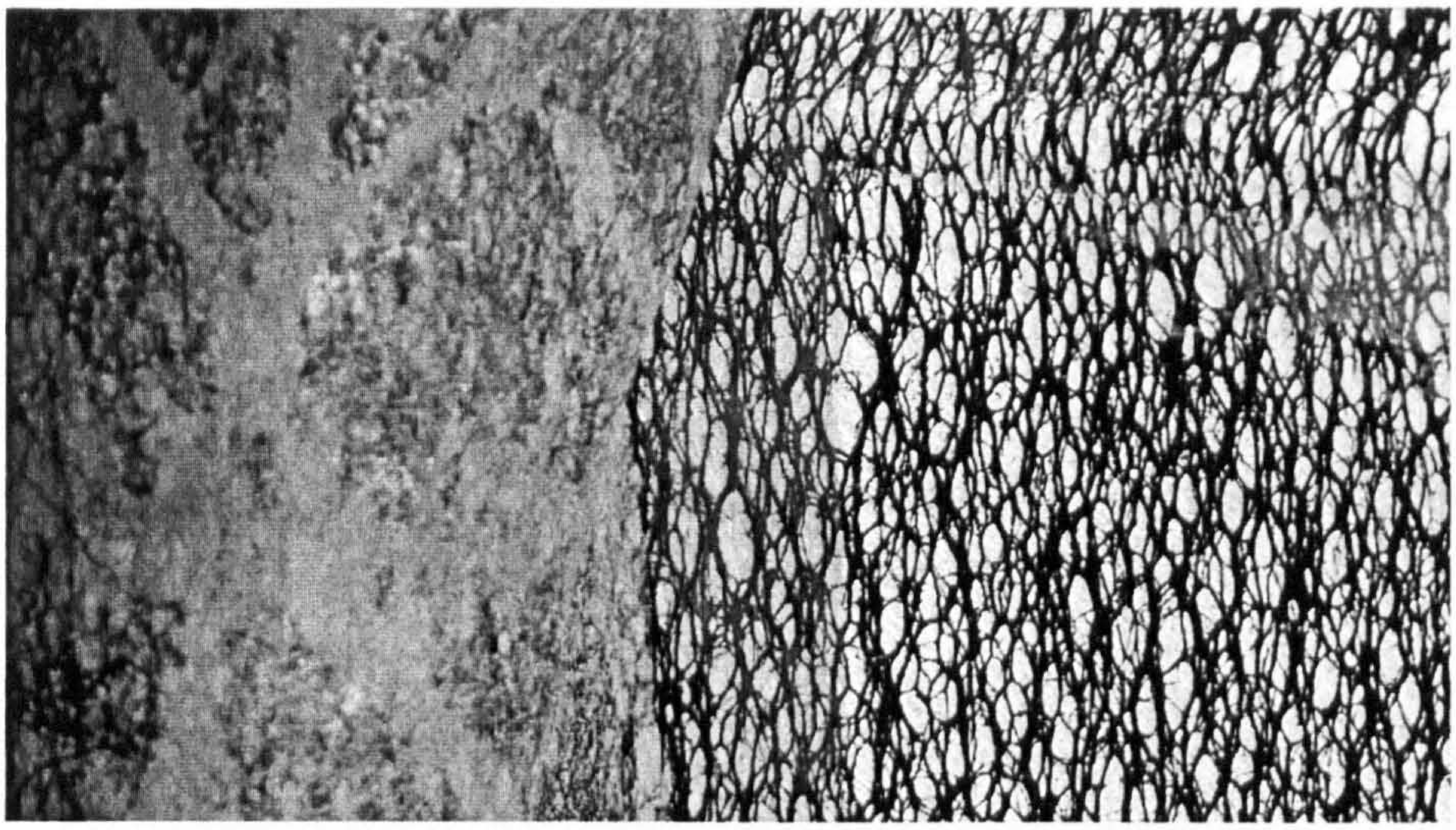
203 (C) Skin prints using fluorescent pigments.
The same area as in Fig. 203 A and B in darkness.

203 A, B, C Screen print patterns are obtained from skin replicas using skeletonization method. The operating principle of this work is based on the phenomenon of photochromy, where the change of colour is due to conditions of light. These textiles are treated with photochromic inks that emit fluorescent green colour under ultraviolet radiation in a dark place, yet maintain their original colour when exposed to natural light.

204, 205 Digital prints on cotton.

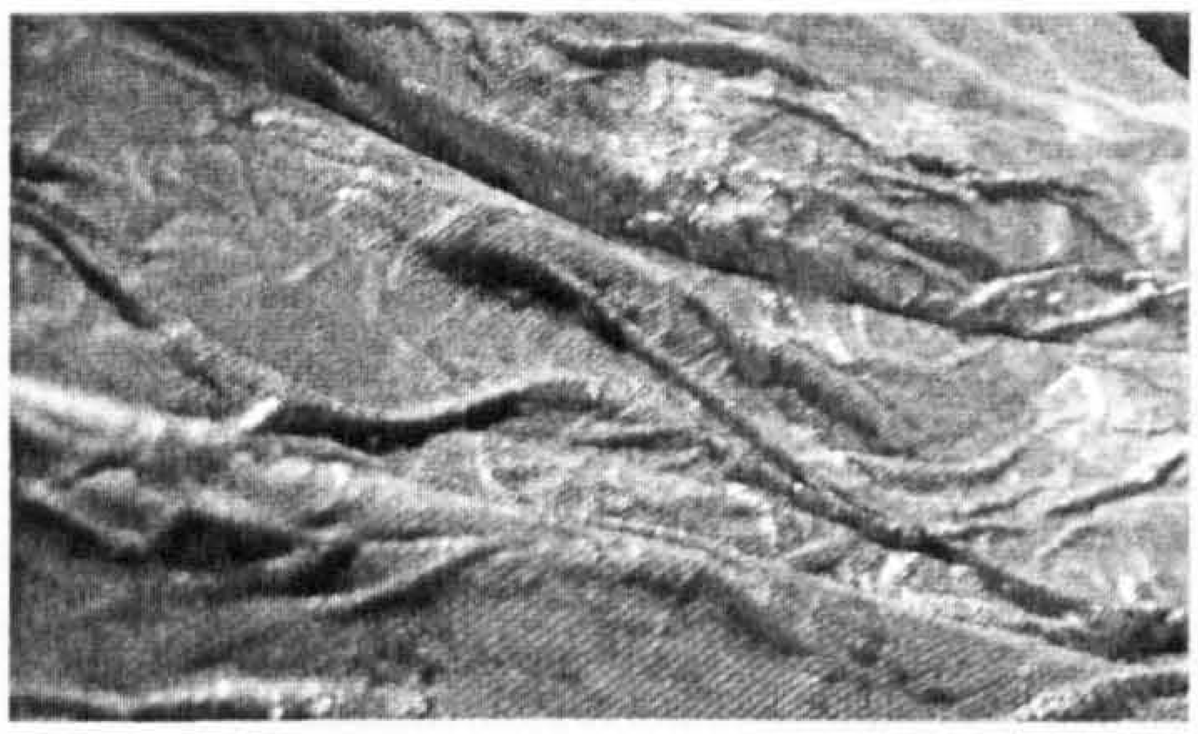

206, 207 Black and white photographic images
on fabrics (nylon, silk).



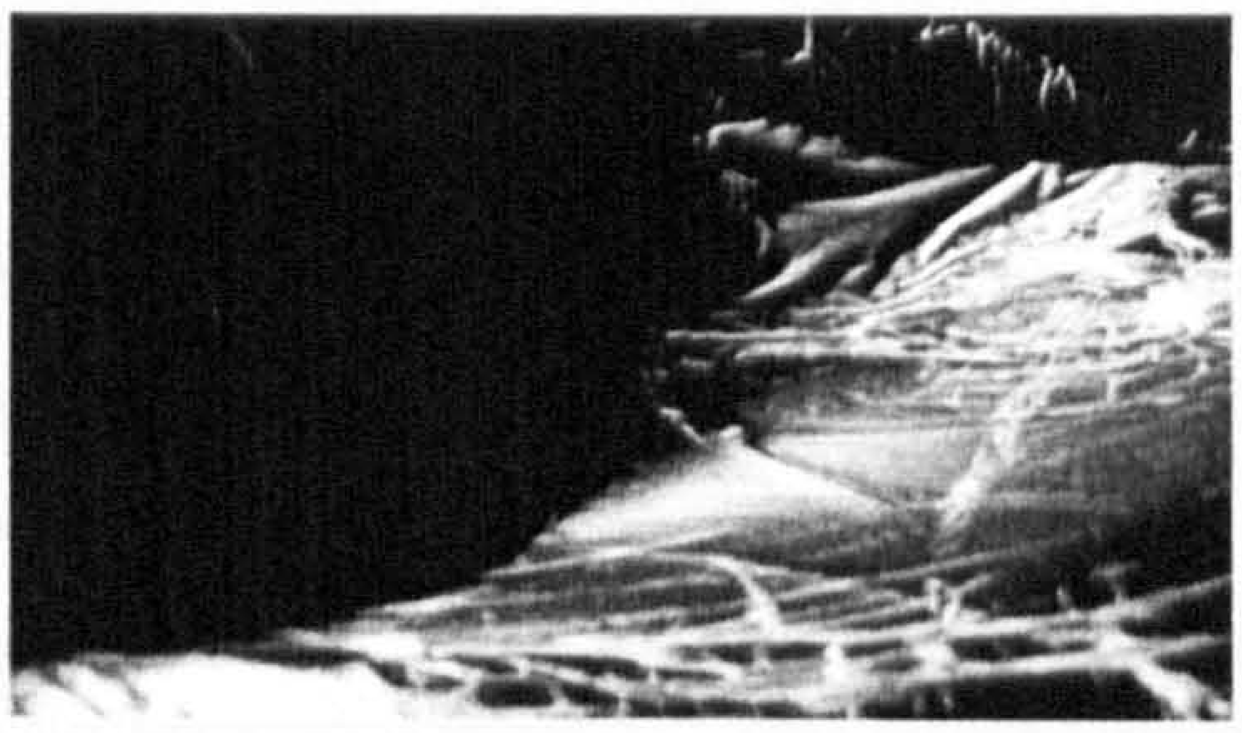
208 Blood vessel network patterns created using metallic foils in combination with adhesive webs.

209 Adhesive web in combination with flock transfers on polyester fleece.

210 Adhesive web in combination with heat transfer printing on polyester nonwoven.



211 Latex coating.



212 Silicone coating on a household foil.

A similar technological process applies for the preparation of digital prints – they were manipulated using Photoshop software (Fig. 204,205). However, for ink-jet prints no colour separation is required, as with this technology it is possible to print multi-coloured and rich patterns without any colour limitations, which is a typical problem for screen printing. As a result of these experiments I produced a range of samples derived from the vivid microscopic images of the skin in various colour ranges printed on silk and cotton (Textile File).

The black and white photographic technology applied on fabrics was also employed and contributed to the practical research with grey scale realistic representations of skin surfaces (Fig. 206, 207). These were found to be particularly impressive when applied on crepe silk, which shrinks when wet and as a result creates a beautiful skin-like surface. A special photo emulsion makes silk hard and the obtained 3-dimensional pattern remains permanent making reference to dry skin.

Adhesive webs made of adhesive mono-filaments in combination with metallic foils were used, creating fabrics that mimic fragile blood vessel net work patterns (Fig. 208). More abstract representations of skin and skin colours were obtained using heat transfer printing, transfer foils, adhesive webs in combination with flock transfers, and simply by printing with an empty screen (Fig. 209, 210). Thermochromic inks were usually printed all-over the fabric surface with no obvious patterns. Latex and silicone coatings were also used to obtain an additional skin-like texture (Fig. 211, 212).

11.4.2 SKIN ARCHITECTURE - FORM AND CONSTRUCTION

The 3-dimentional aspects and construction of the epidermis and dermis are particularly exciting. With the help of high power microscopes it is possible to zoom into tiniest structures of the skin, which reveal amazing architectural shapes and forms. These constructions inspired me in my three-dimensional representations of the skin resulting in sculptural textile surfaces and objects.

11.4.2.1 MEMBRANES

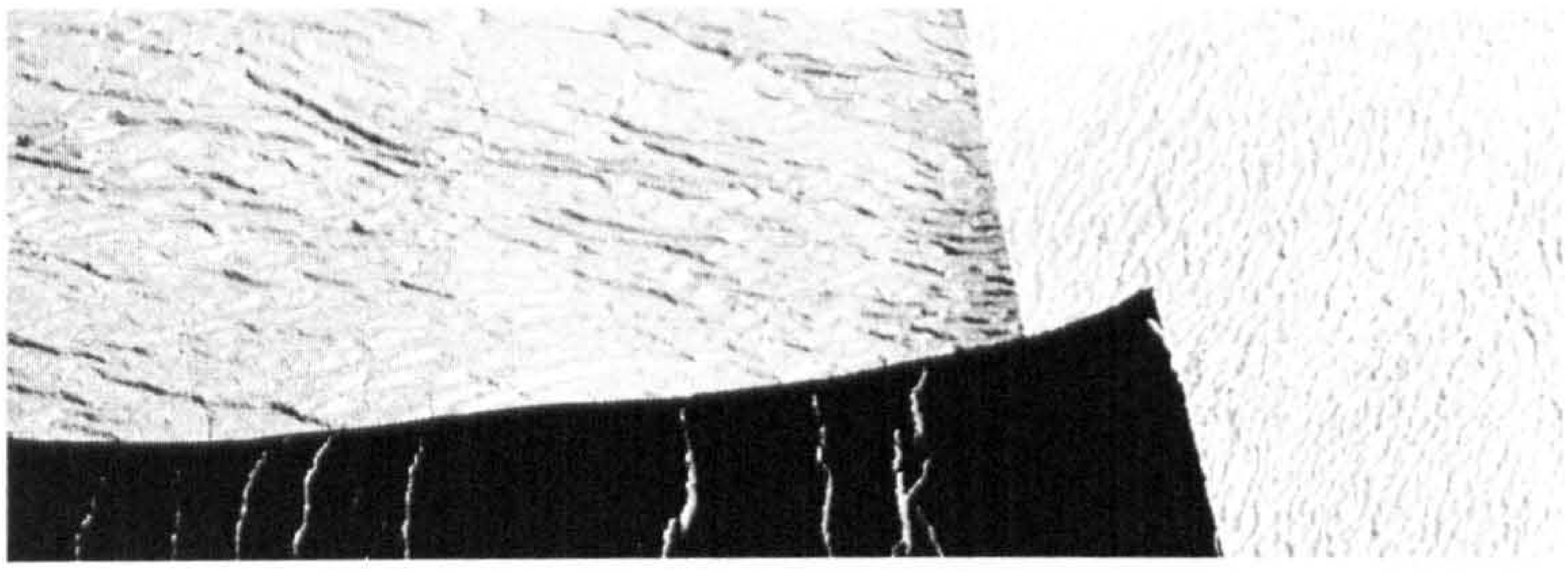
Surfaces coated with silver ink for high performance finishes (11.3.2) have to be baked at 180°C for 5 minutes to improve the conductivity of silver, which in turn improves the fabric's resistance to electrostatic discharges. As discovered during my tests, silver ink coatings on Polyolefin foam sheets create unique surface patterns at high temperatures. Polyolefin foam shrinks in response to heat but a sheet surface coated with silver ink cannot shrink. The difference in material behaviours creates an exciting 3-dimensional skin-like surface structure. The same phenomenon was observed when using carbon ink in combination with the Polyolefin foam (Fig. 213).

A 100% woven crepe silk made of S-warp and Z-weft was used in order to obtain a specific three-dimensional surface pattern that occurs after water has been applied to the fabric, causing it to shrink. In order to emphasise this effect, MANUTEX solution and photo emulsion coatings were used to obtain temporary and permanent fabric stiffness. In some cases sugar water was applied to crepe silk in order to gain a temporary 3-D effect prior to discharge printing, which adds to sophisticated final surface effects (Fig. 213, 215).

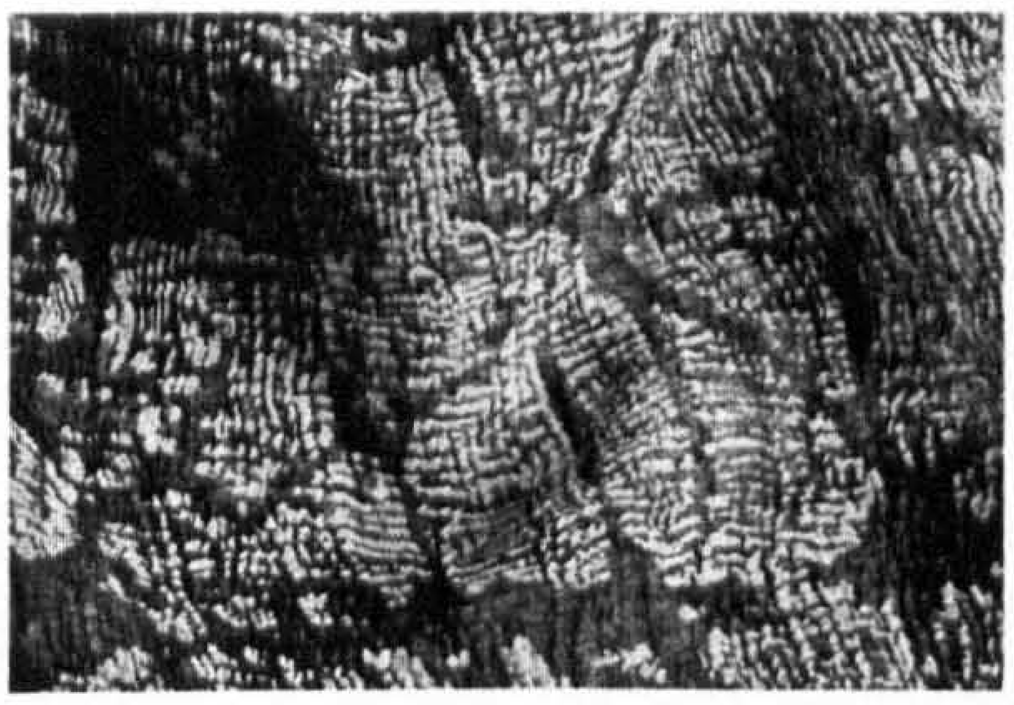
Another means of achieving more controllable relief patterns is the use of puff pigment. This pigment, screen printed on a fabric, expands when heated and creates puckered three-dimensional effects (Fig. 216, 217). The print patterns used were obtained as described in Section 11.4.1.

Skin is a multi-layered organ and to address this aspect, special thermoplastic adhesive webs, which can be activated by heat, were used for bonding two or more layers of different fabrics together. (10.2) Transparent thermoplastic foils or pre-printed inkjet films were also used to laminate different textile surfaces in sections or overall (Fig. 218-220).

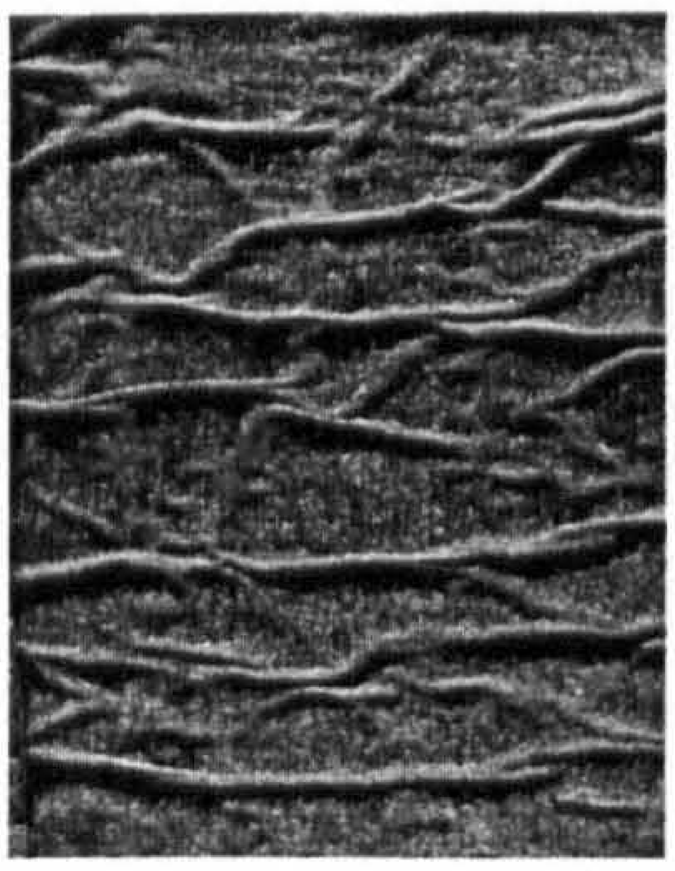
Pure or coloured silicone was applied in thick layers on substrates such as household foils, latex and baking paper to produce surfaces which have certain fleshly qualities suggesting body tissues under the skin or smoothness of the skin itself (Fig. 223). In some cases pieces of cloth, threads or dry latex drops were integrated between the layers of silicone or latex in order to obtain irregular surface and/or certain three-dimensional patterns referring to the network of underlying blood vessels and capillaries.

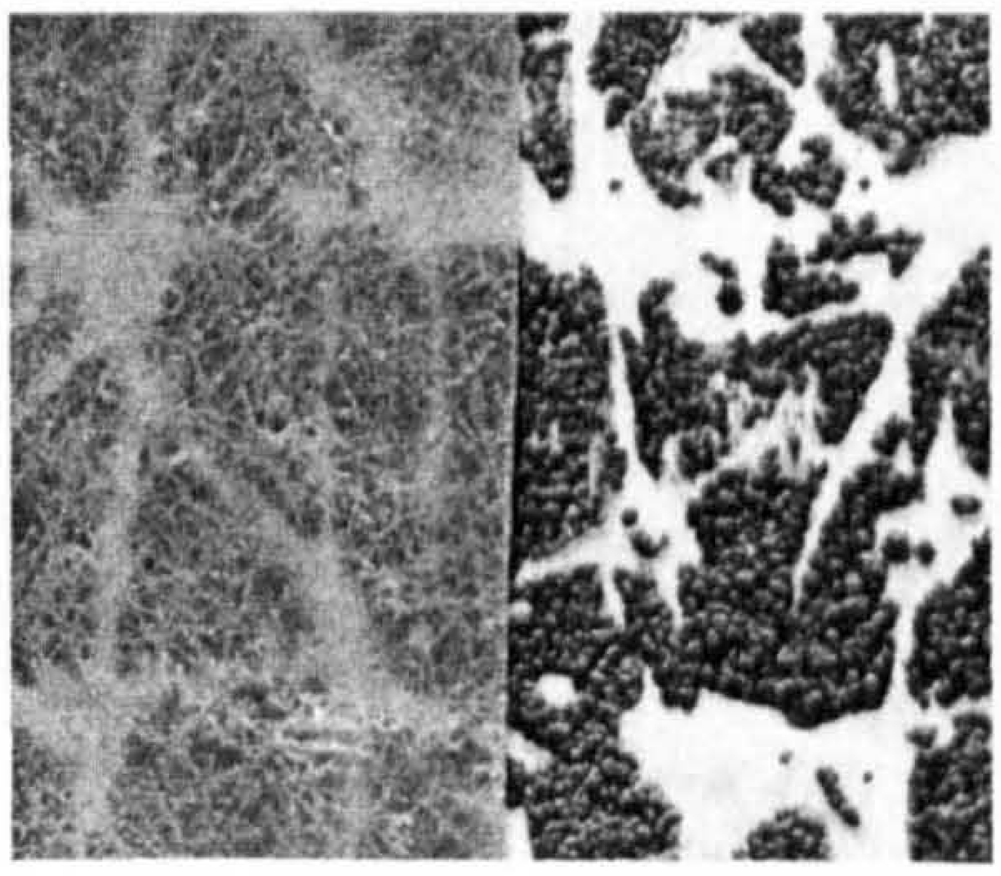


213 Polyolefin foam coated with silver and carbon inks. While baking, the Polyolefin foam shrinks in response to heat and creates dimensional skin-like surface patterns.

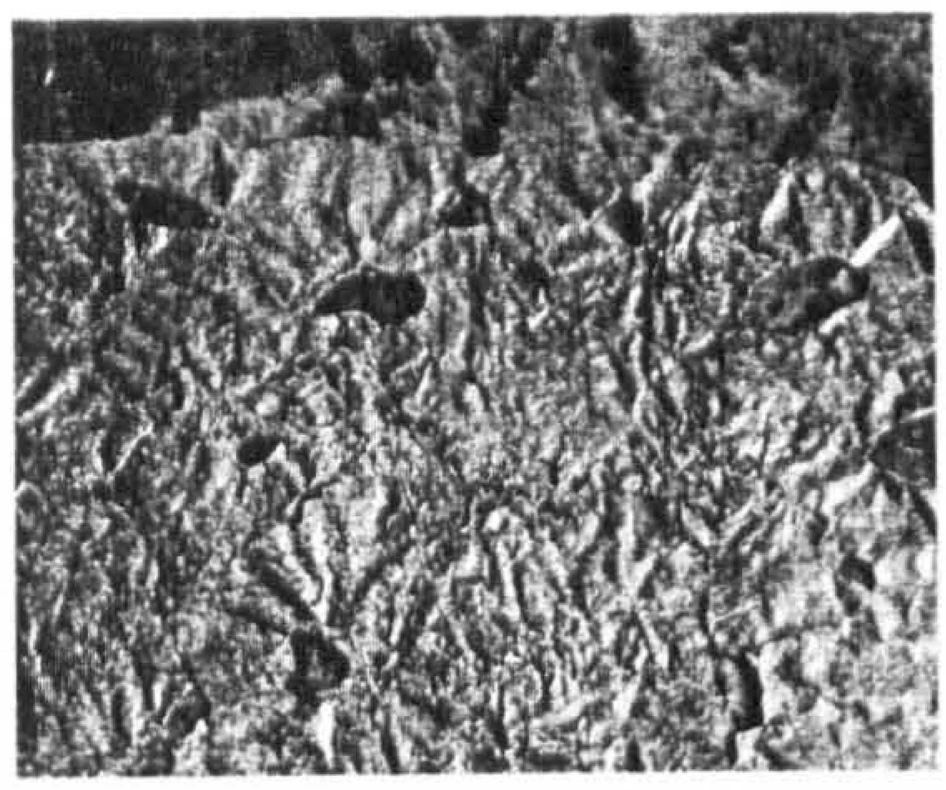


214, 215 Three-dimensional surface patterns achieved on crepe silk prior to discharge printing.

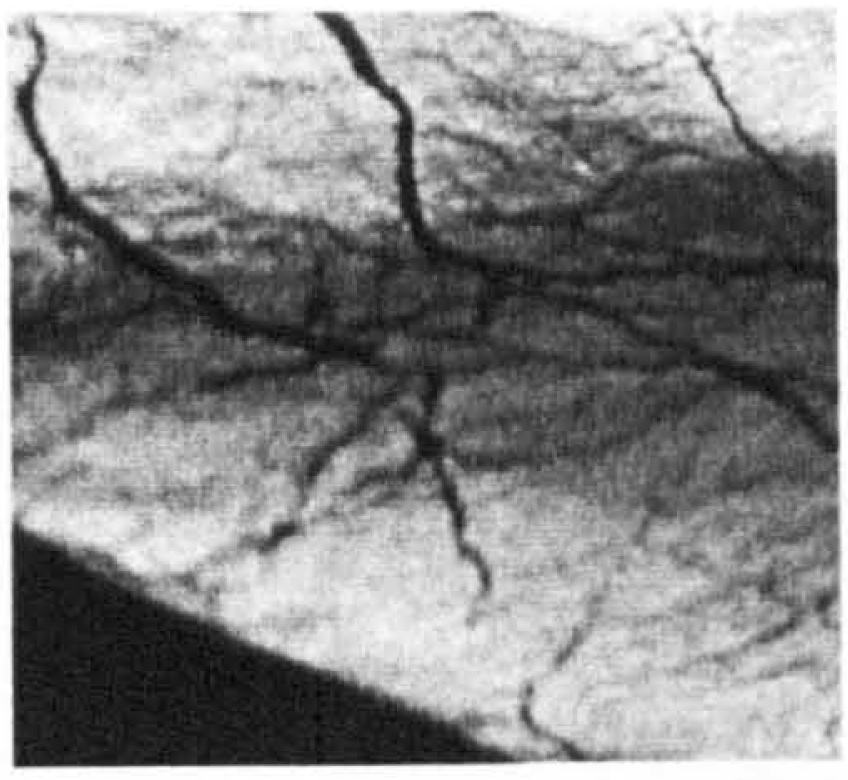




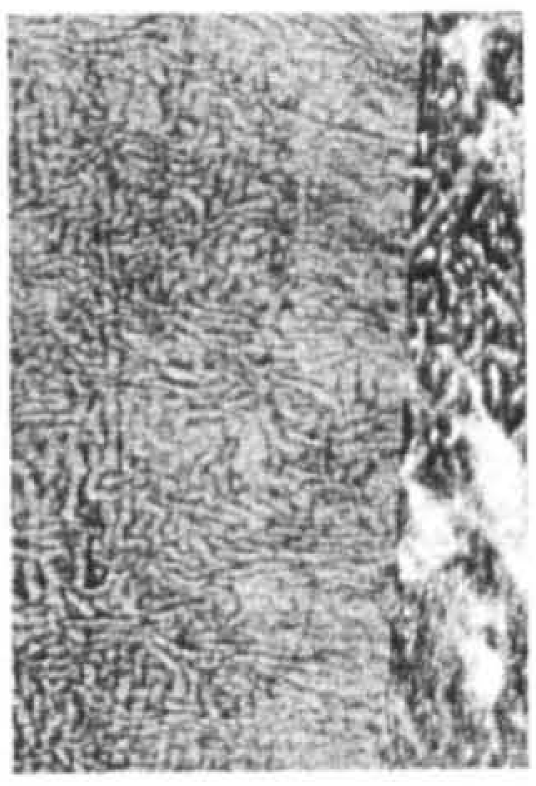
216, 217 Three-dimensional surface patterns achieved using puff pigment print.



218 Nonwoven laminated with
pre-printed ink jet foil and partially burnt.

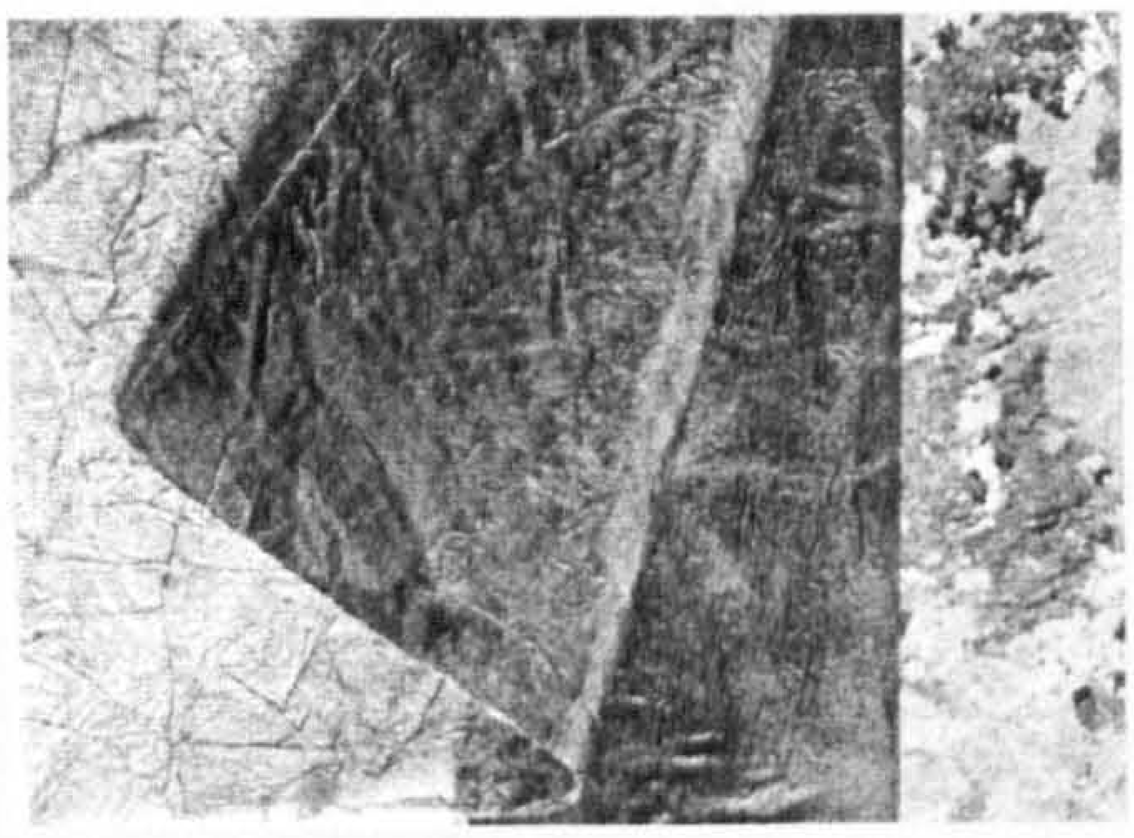


219 Silk bonded with transfer printed nonwoven.

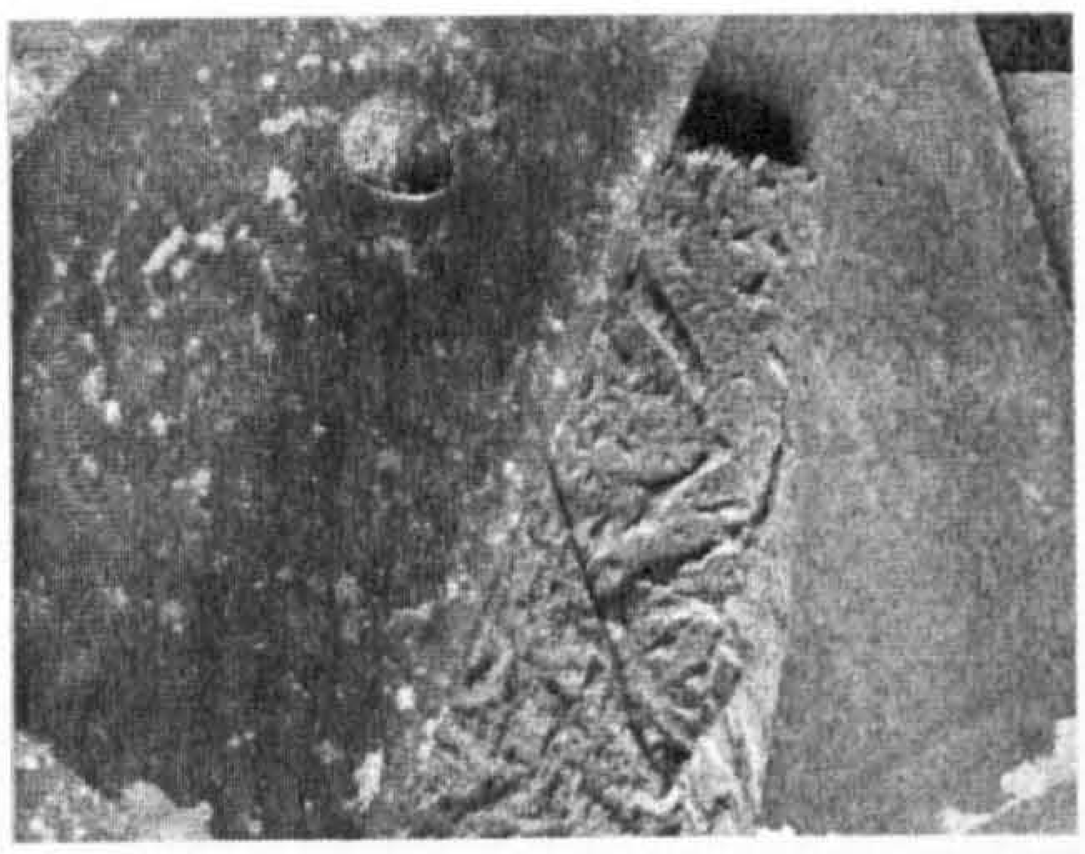


220 Fine nonwoven laminated with thermoplastic foil.

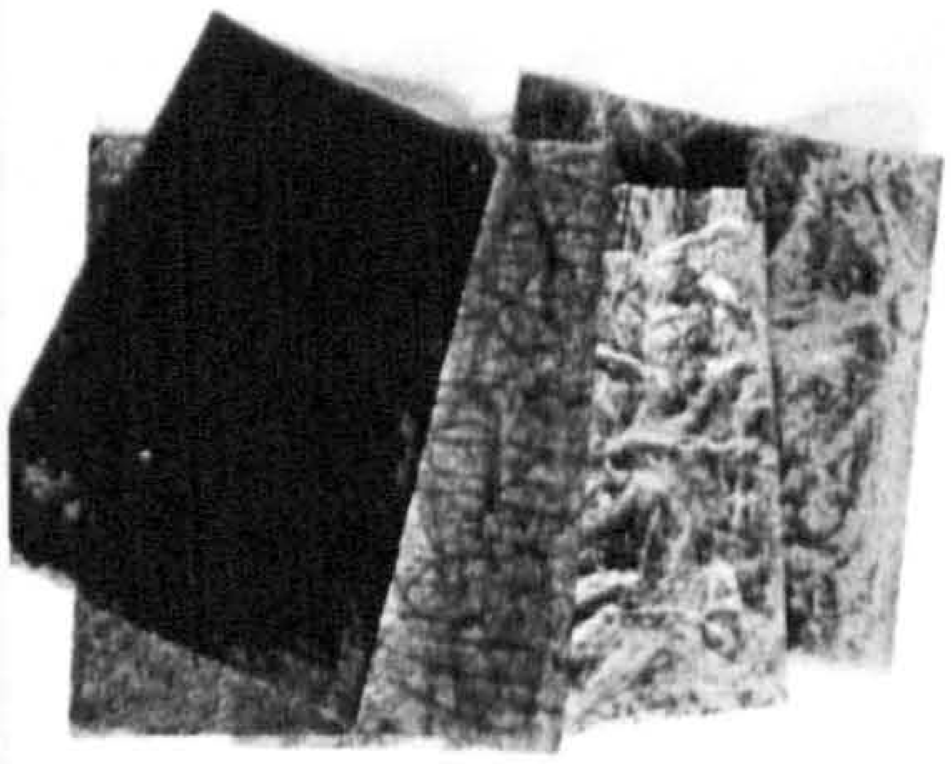
221 Layering, fleece,
metallic foils.



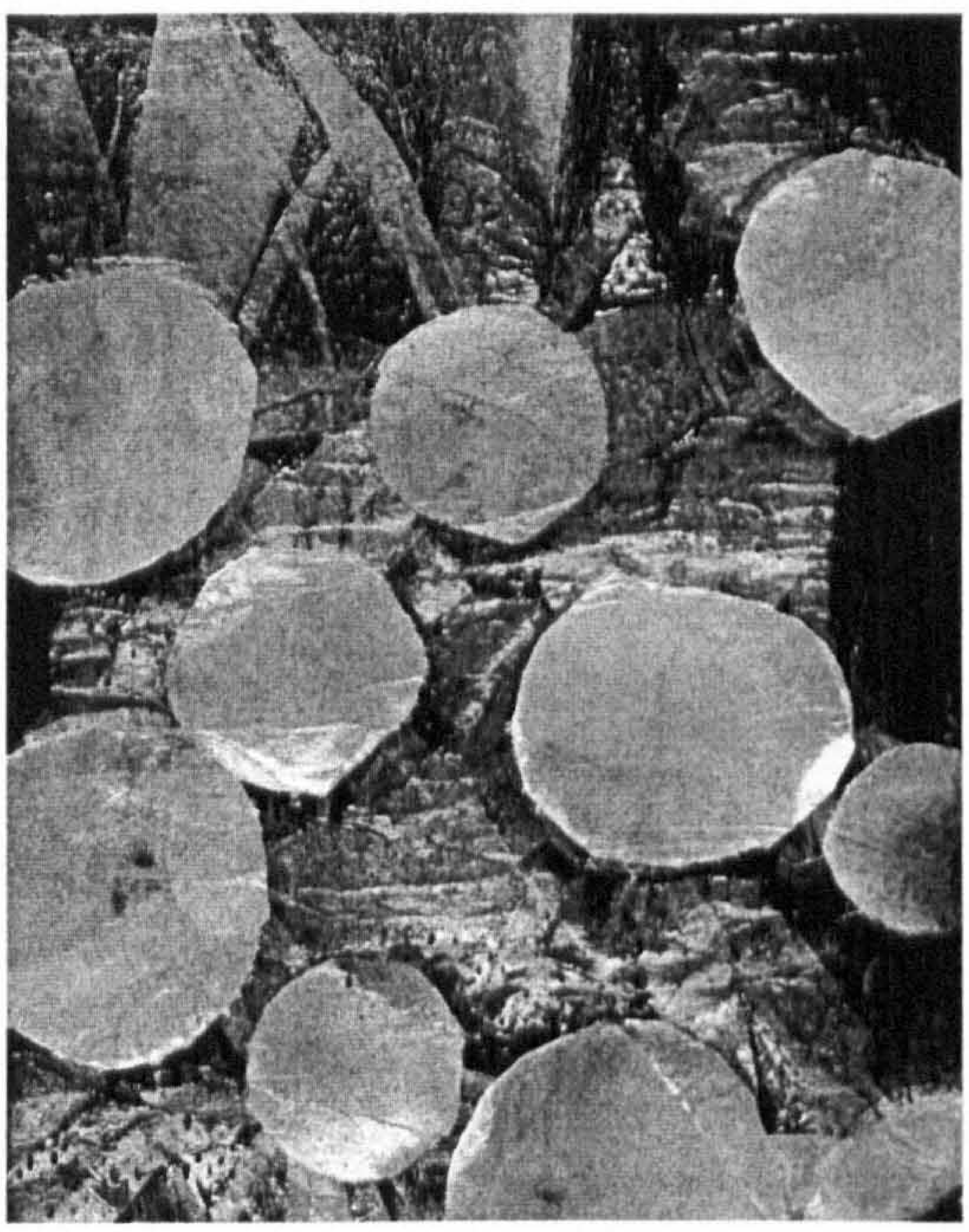
222 Various coatings: ink jet film, thermoplastic foil,
silicone, nonwoven, metallic foil.



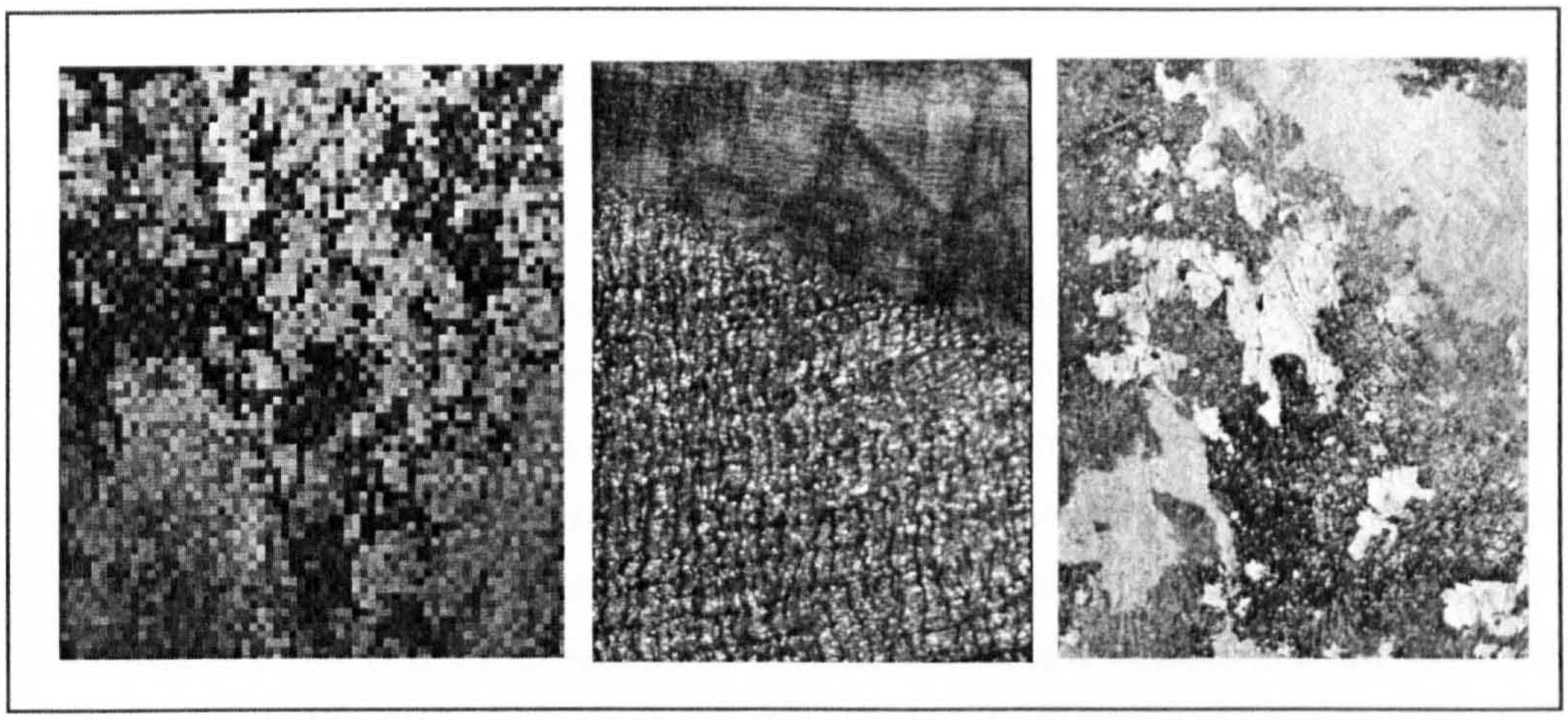
223 Various coatings: silicone, latex,
photo emulsion.



224 Laminated fabrics: pre-printed ink jet film and
thermoplastic foil on digital prints.



225, 226 Skin cells, nonwovens, adhesive web, heat press.



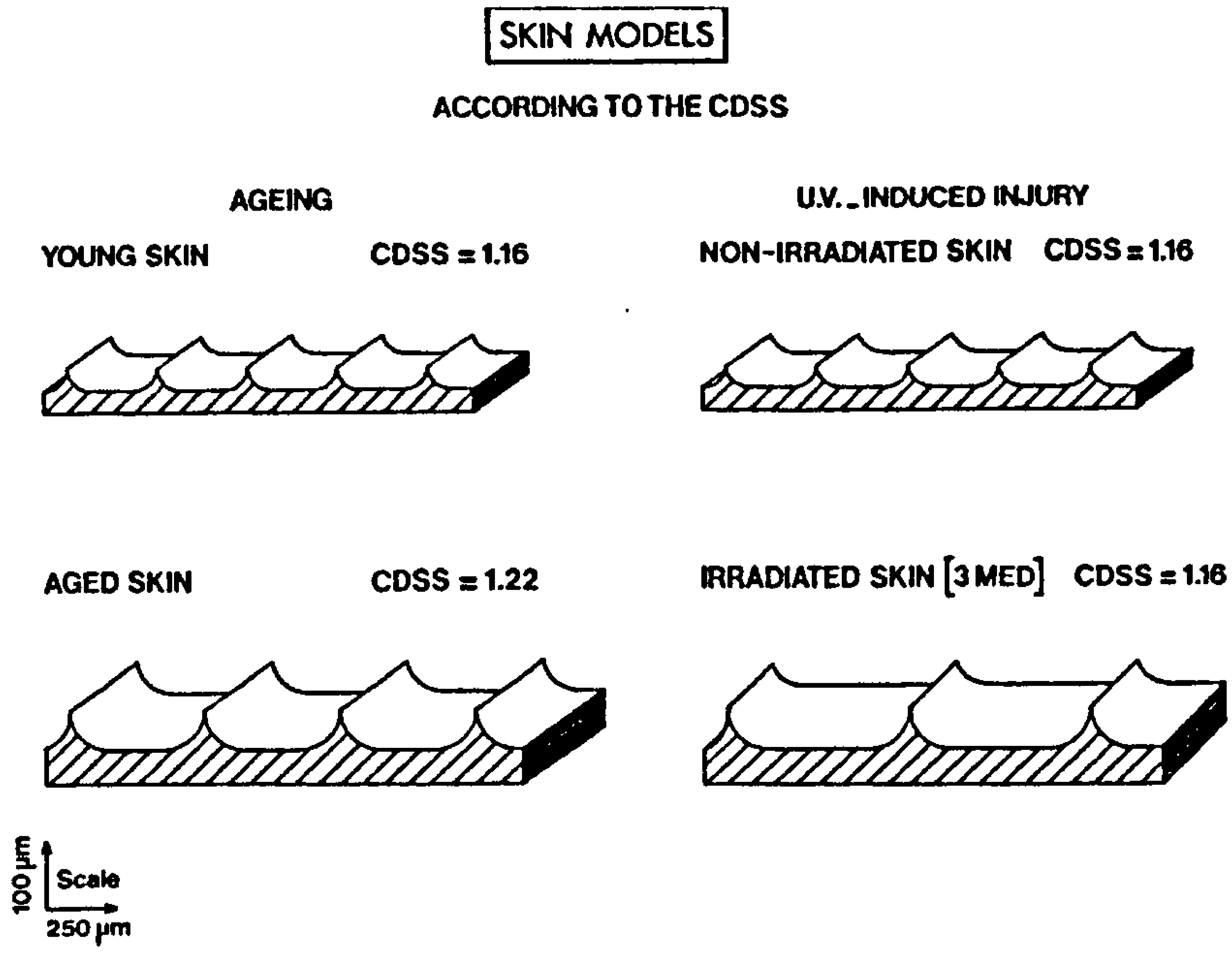
227, 228, 229 Dry skin, latex, silk, net, metallic foil, stiffener (photo emulsion).

Dead skin cells constantly fall off the epidermis and are not visible to a naked eye, but by employing an electron scanning microscope it is possible to see curious landscapes of epidermal cells. I incorporated these into textiles using a thermo-moulding technique in order to produce three-dimensional skin cell shapes. Various nonwovens with good thermo-plastic properties were employed in combination with heat transfer printing, transfer foils, laminates and silicone (Fig. 225, 226).

Additionally, the entire SKIN STORIES :: CHARTING AND MAPPING THE SKIN collection was concerned with the tactile qualities of the new textiles. This aspect was constantly explored using the technologies and materials as described above in this chapter. The inherent skin-like haptic qualities of latex, silicone and silk were emphasised through the use of various textile techniques applied to them. By means of stiffening, baking, embossing, coating and laminating, layering different materials one on top of each other allowing them organically to connect, and fluently transforming the surfaces from one structure into another, intimate skin landscapes are created. These offer a range of tactile and visual experiences, which reveal to a viewers eye and hand. The generated textile surfaces carry tactile references to variety of epidermal states from smooth, soft to dry, disturbed or shed skin (Fig. 227-229) and provoke immediate emotional responses upon touching.

11.4.2.2 OBJECTS

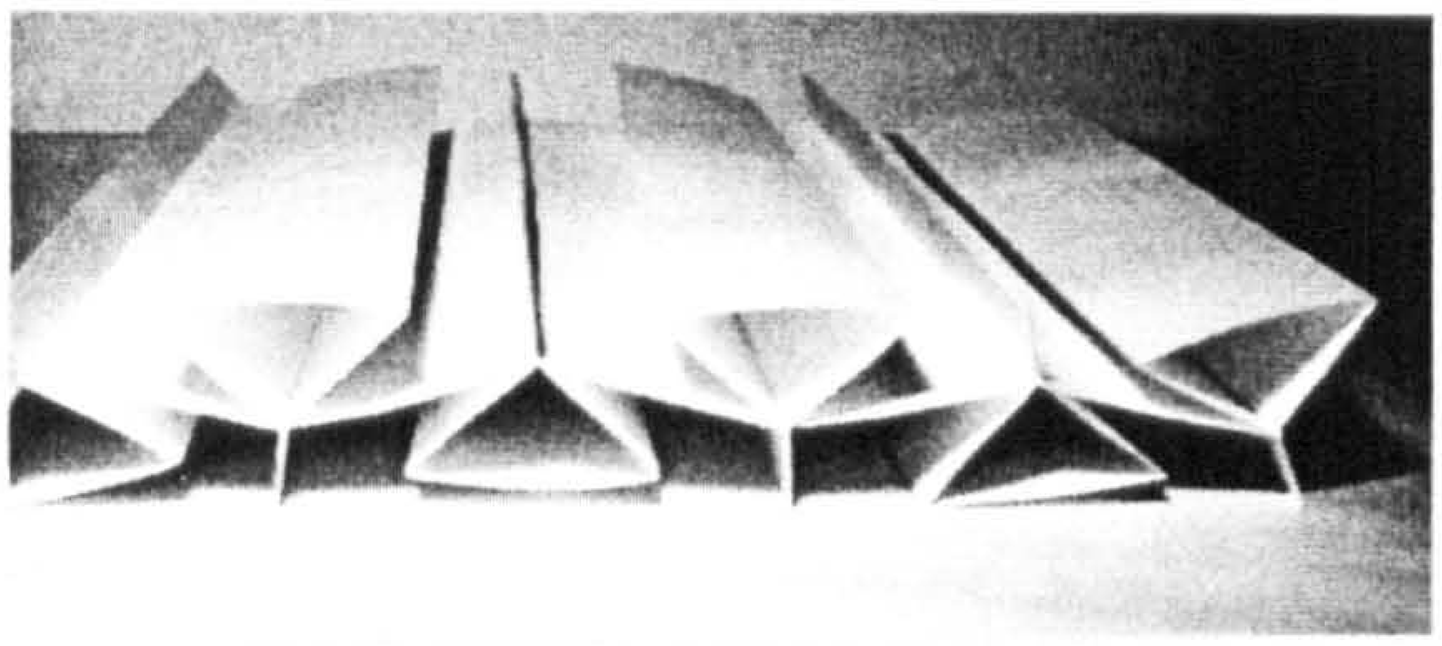
During the experimental phase a range of tests have been conducted with an aim to explore the three-dimensional relief characteristics of the skin for the development of sculptural textile design products or art pieces. Magnified surface patterns of the dermis were selected and then these were simplified and rationalised to their basic lines and forms so that large objects such as dimensional wall structures and space dividers can be developed. For this purpose the 'shadowing principle' of skin surface area was applied (typically used in dermatology, see 08.4) in order to obtain a basic structural grid for the development of new architectural membranes.

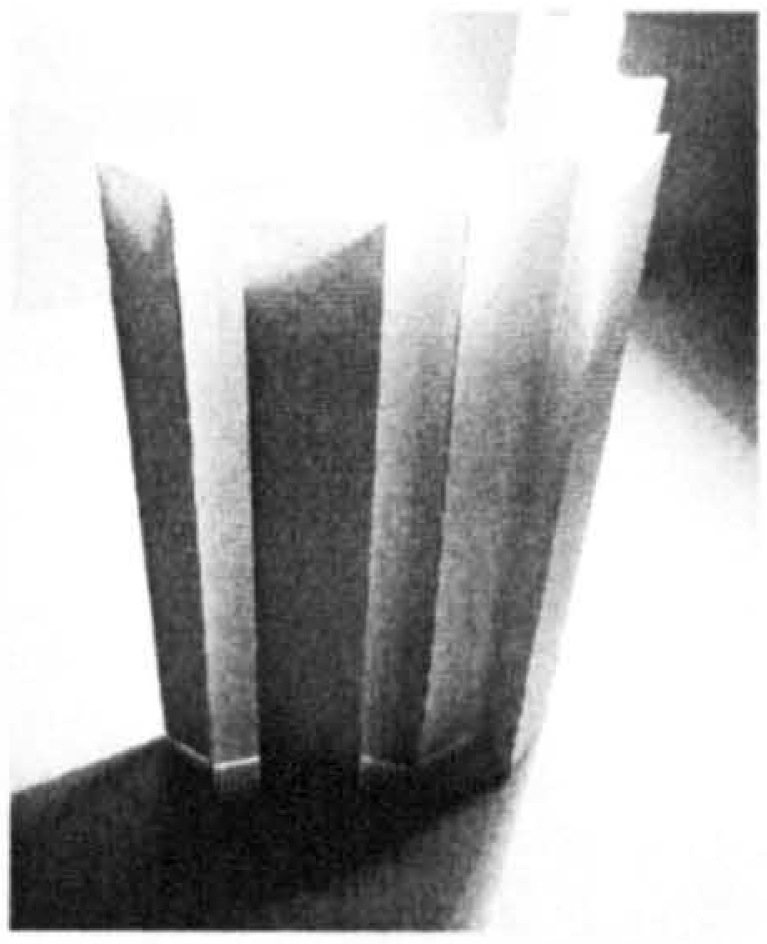


230 Skin models.
These models were used as an analogy for the development of architectural membranes.

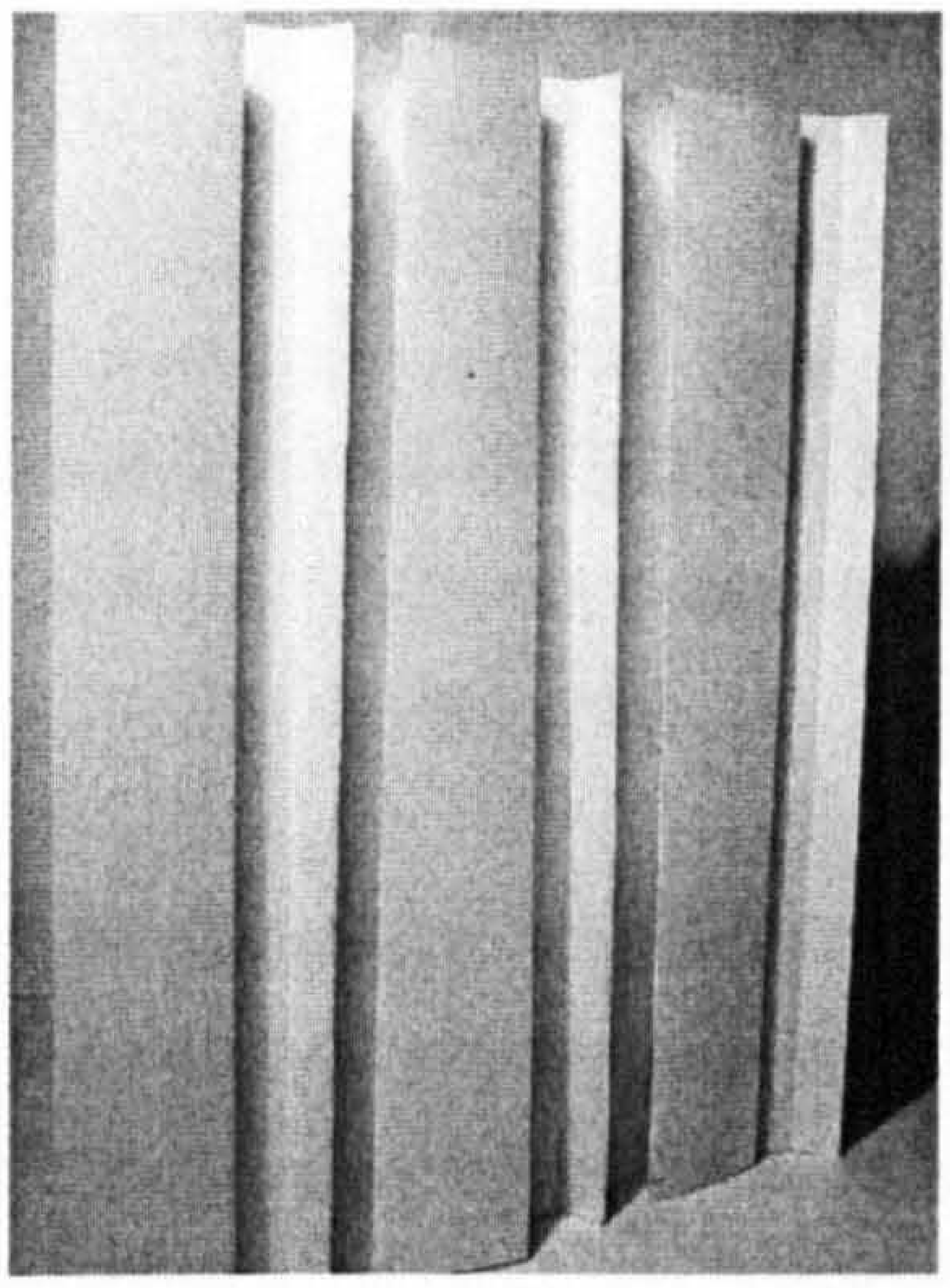
As a part of an exercise, I was interested into creation of objects for interior that have flexible structure and that are freestanding but, which consist of an outer 'skin' only. First three-dimensional tests were executed in paper to find out possible structural variations for self-sustaining constructions. If the base structure were found stabile, further prototypes were executed in cardboard or using nonwovens as base materials (Fig. 231-237).

The attempts to facilitate the skin relief characteristics using the 'shadowing principle' (Fig. 150) resulted in several small size working prototypes, which in future can be developed into large scale design products for interiors. All of them demonstrate good freestanding properties and some can be compressed or expanded on their vertical sides to obtain the desired shape or volume making reference to the elastic qualities of skin. Later one of the mock-ups (Fig. 236) was brought forward to a large prototype scale as described in next Chapter (12.2). Pulsating Object was additionally equipped with interactive properties of thermochromic ink in combination with electric heaters, so transforming into an object created of 'living skin'.



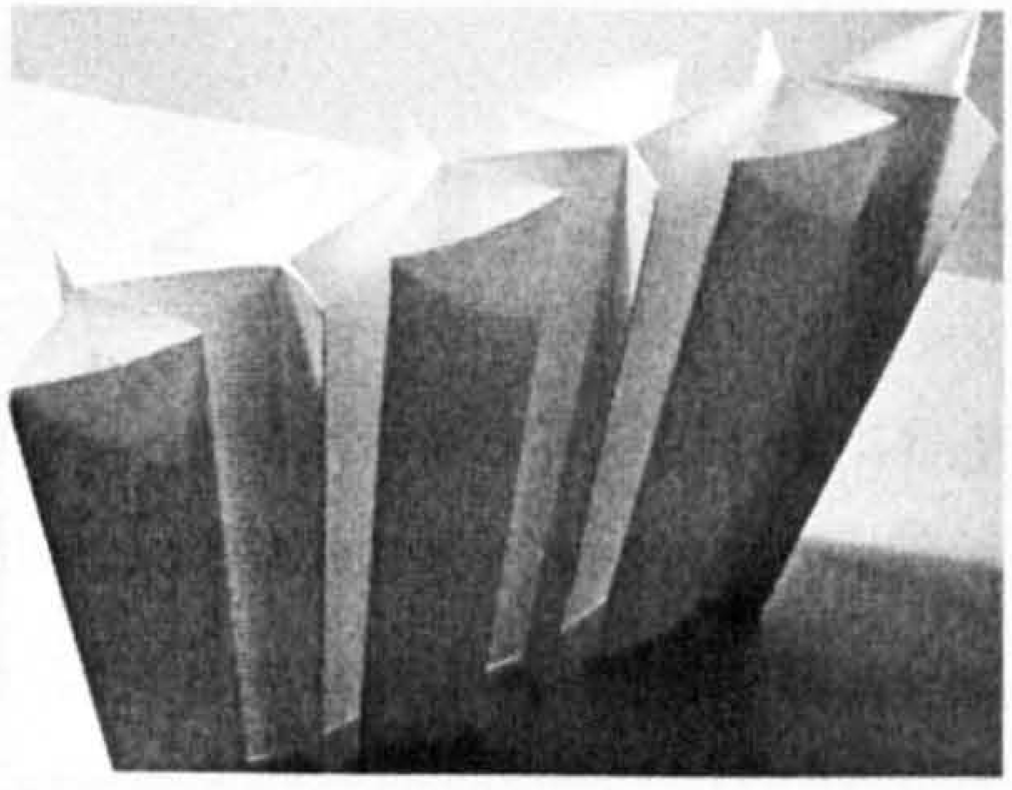


231 A, B

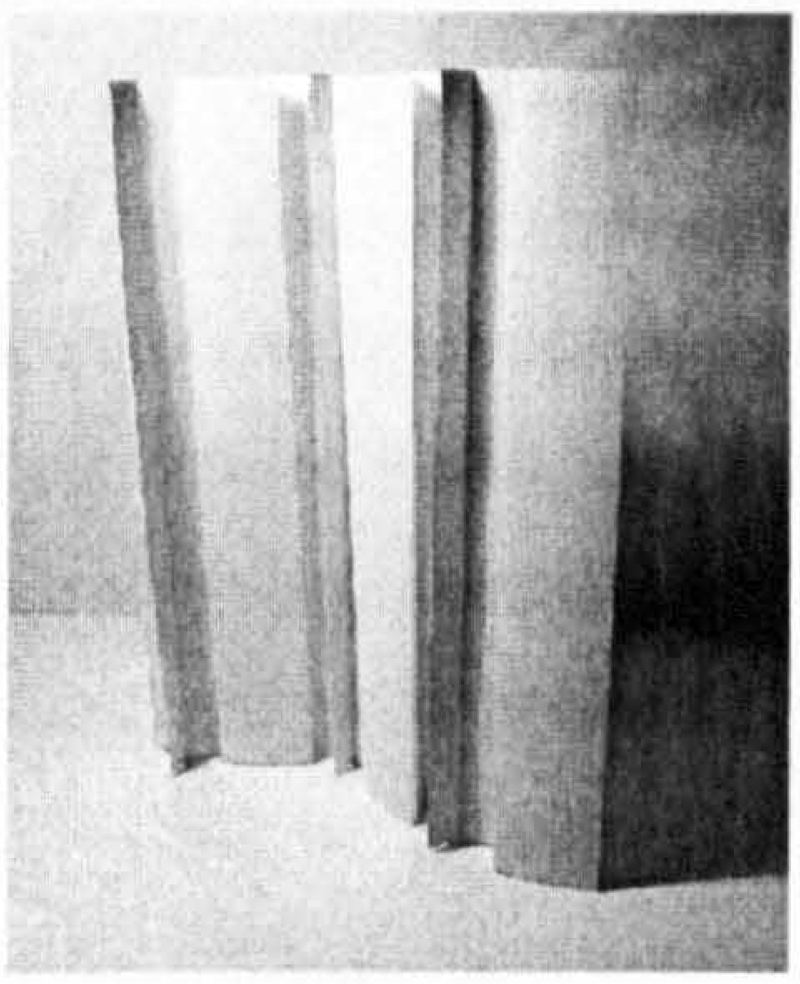


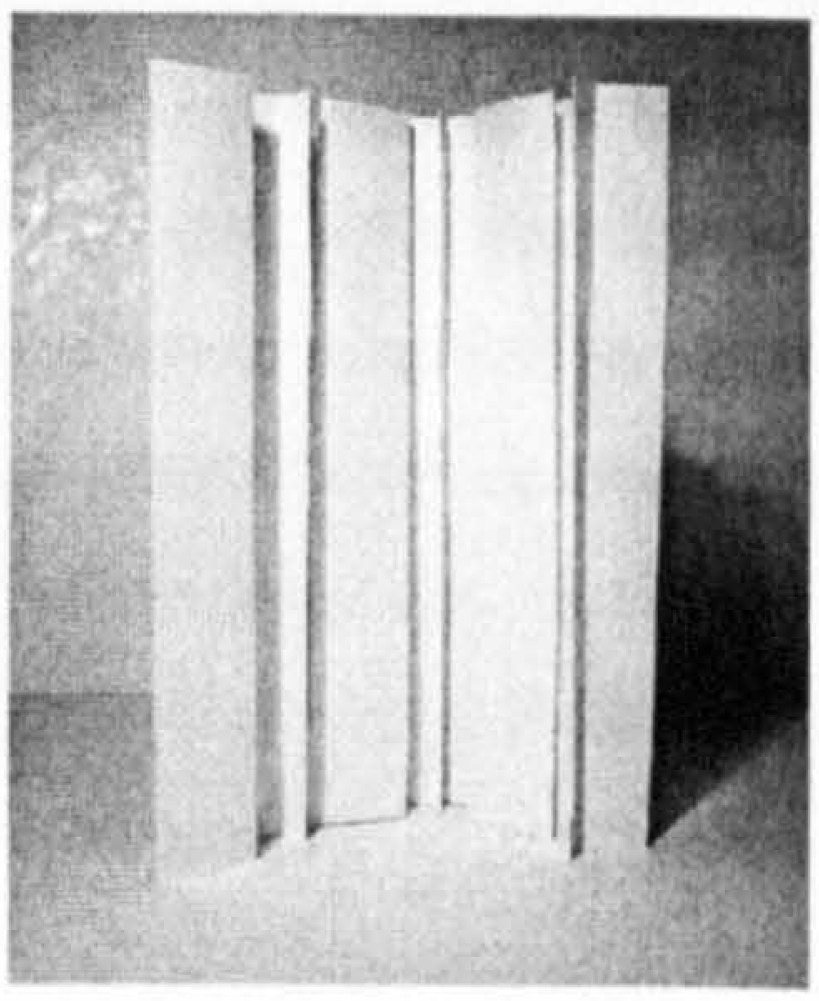
231 A - F Paper folds.

Experimental mock-ups for the development of architectural textile membranes. Analogy used is that of skin's surface as seen in Figure 230.

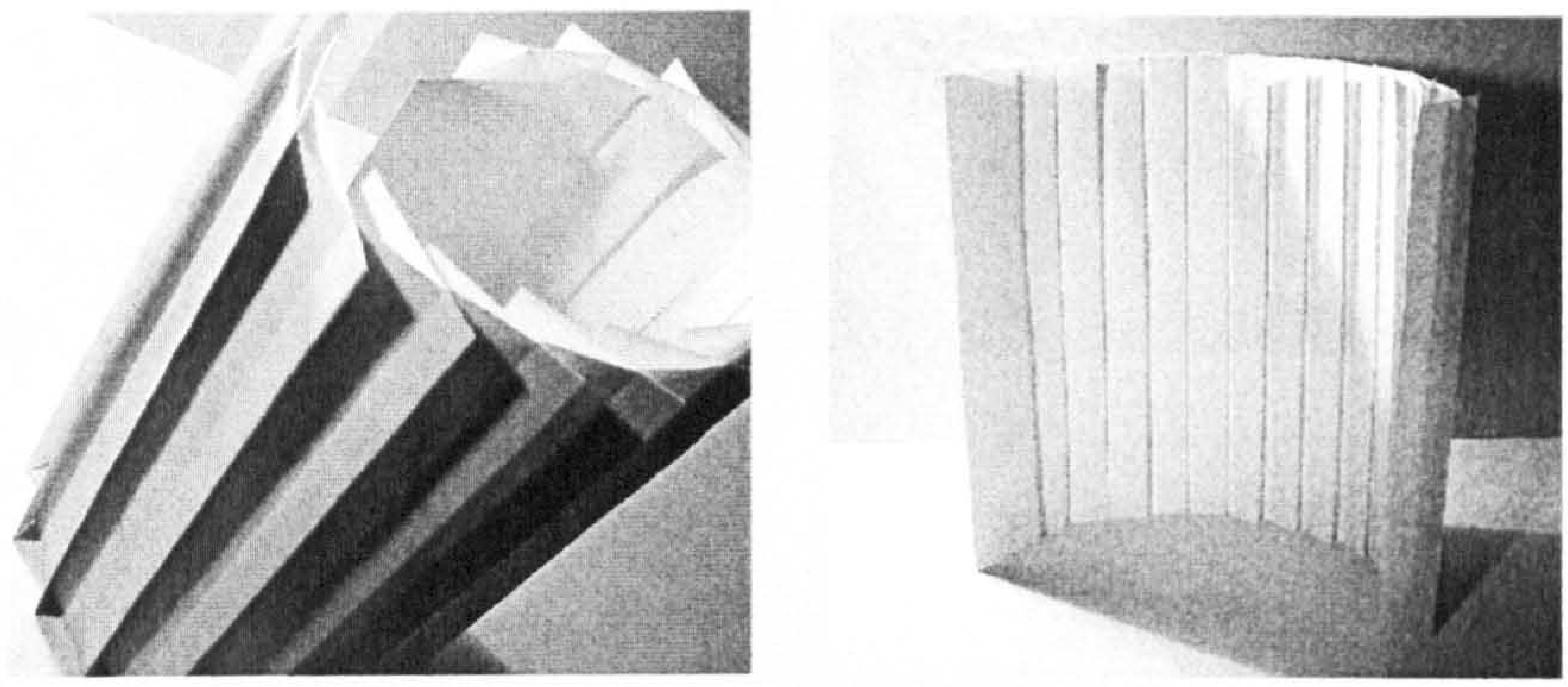


231 C, D

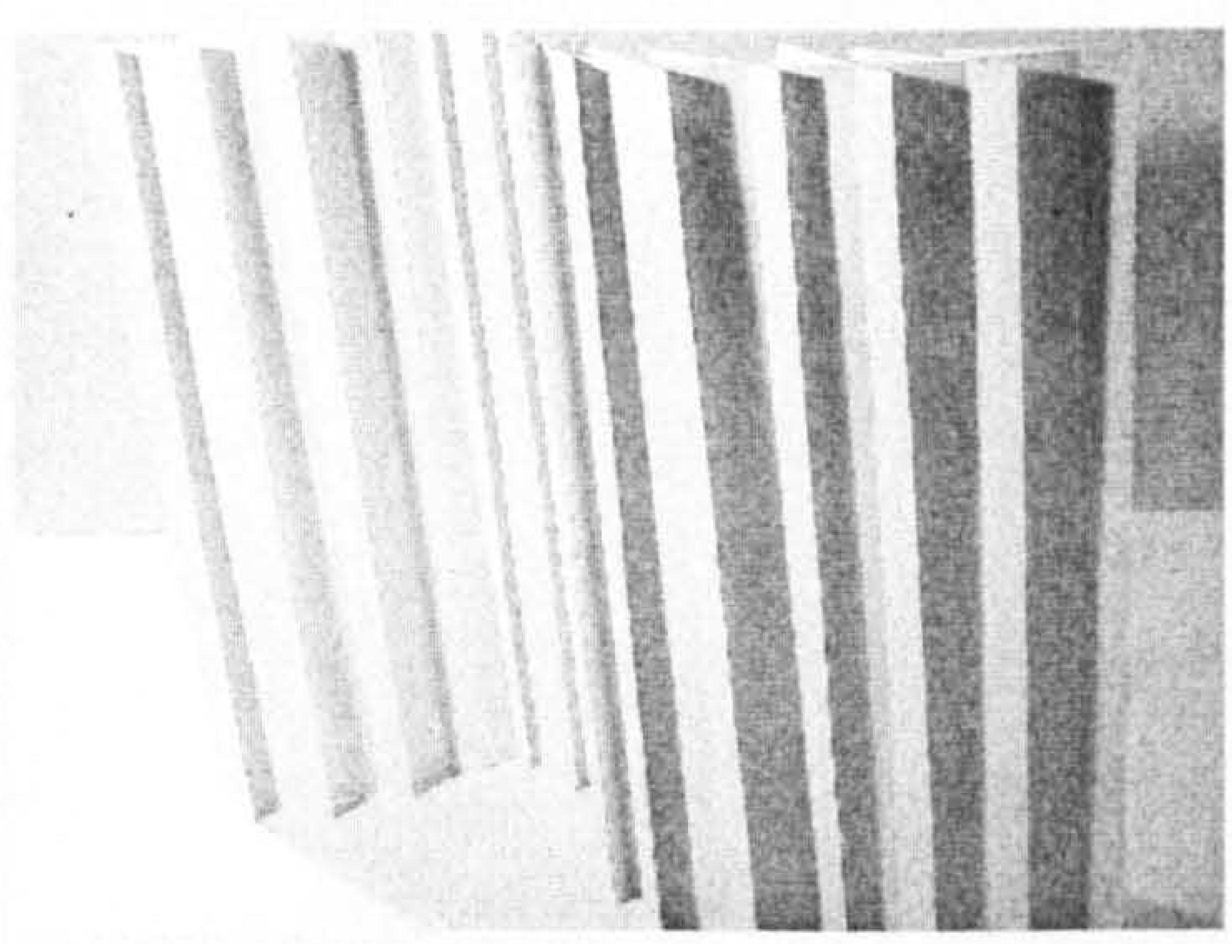




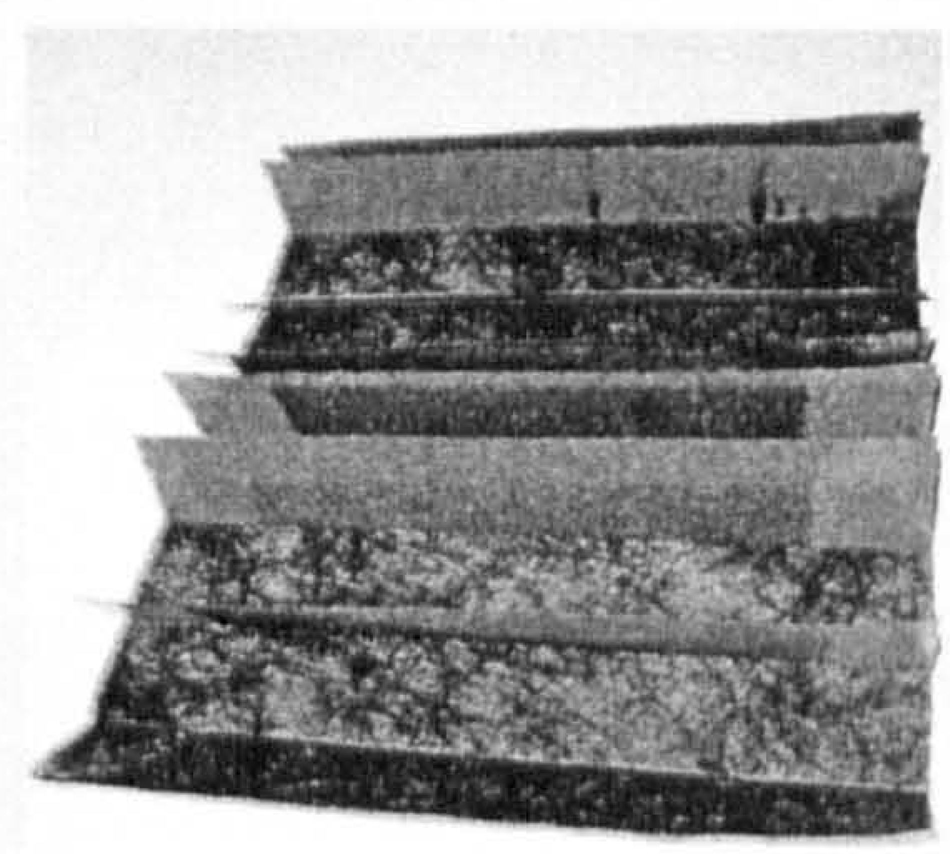
231E, F



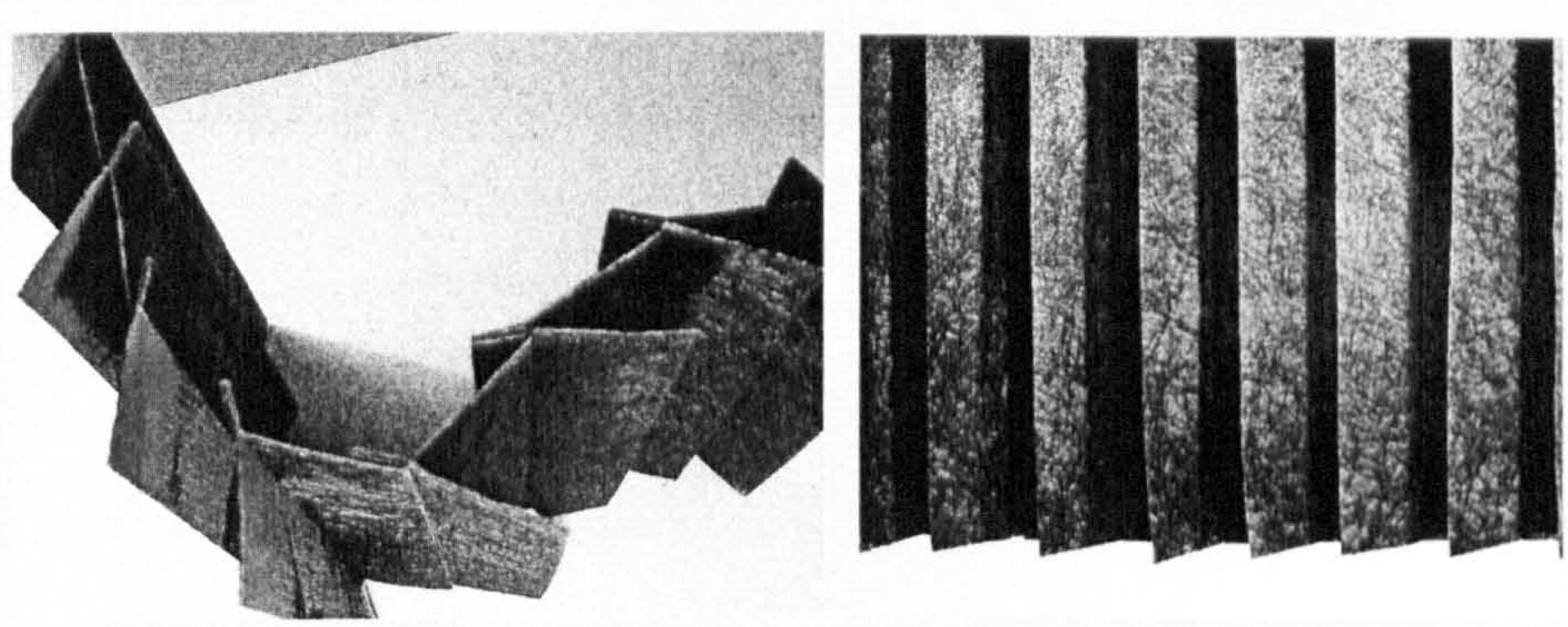
232 A, B Paper mock-ups.



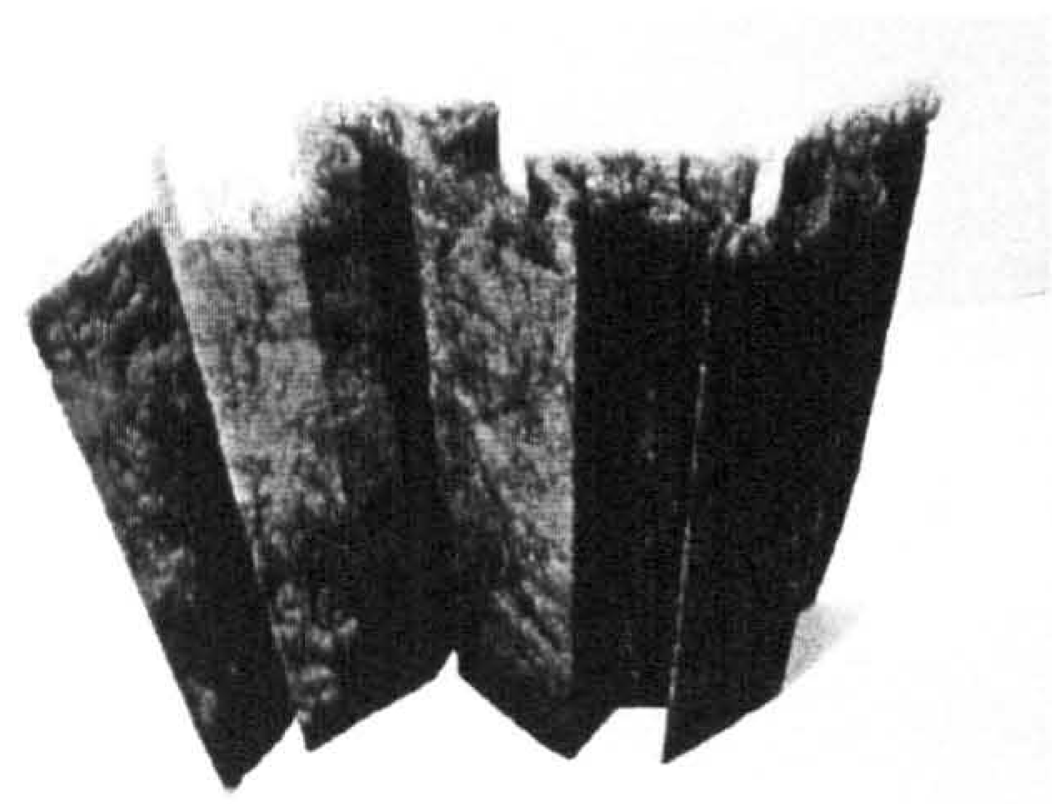
232 C Paper mock-up.

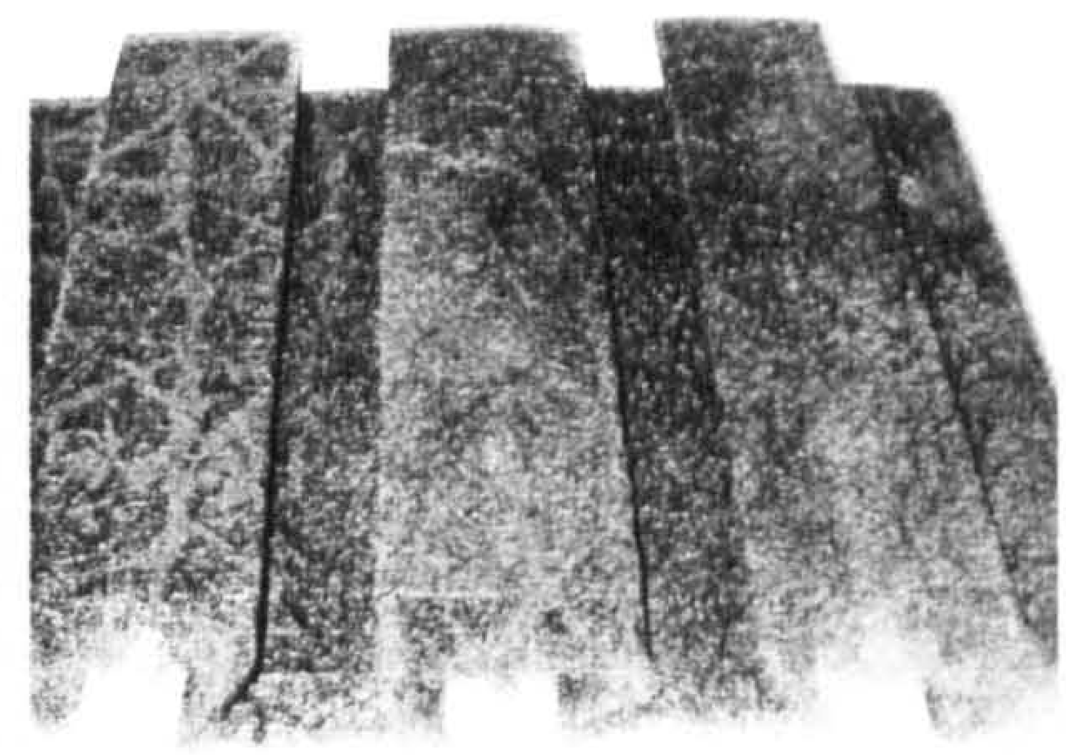


233 A Textile prototype using the same principle as in Fig. 232 A - C.

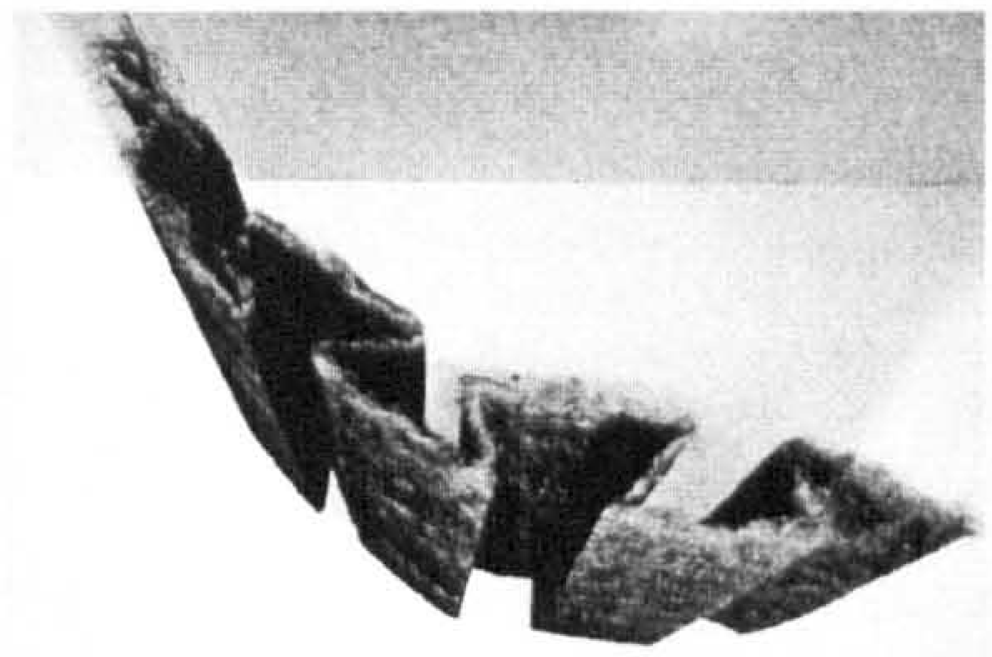


233 B, C Textile prototypes using the same principle as in Fig. 232 A - C.





234 A, B, C

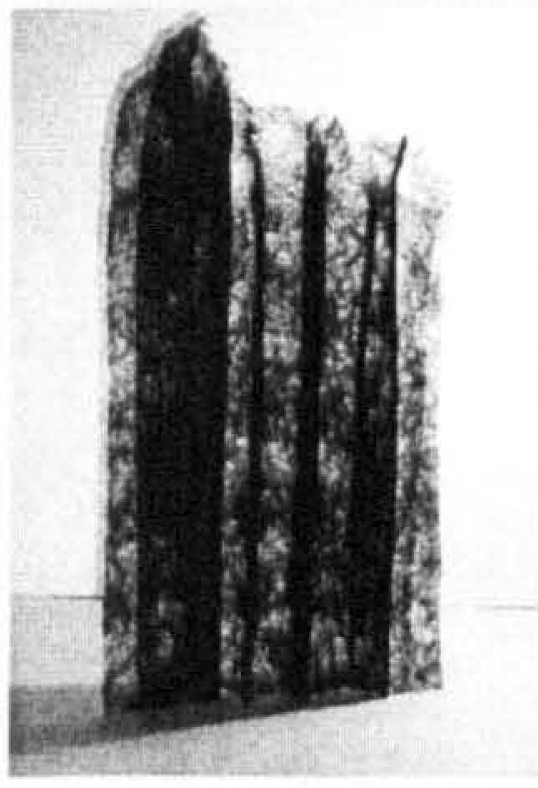


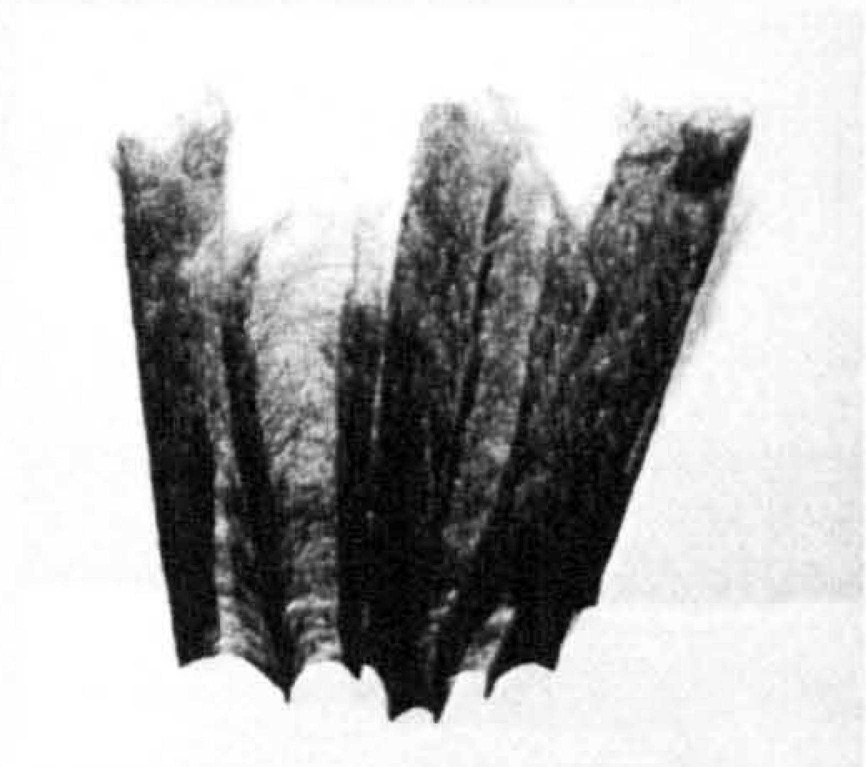
Experimental mock-ups for the development of architectural textile membranes. Analogy used is that of skin's surface as seen in Figure 230.

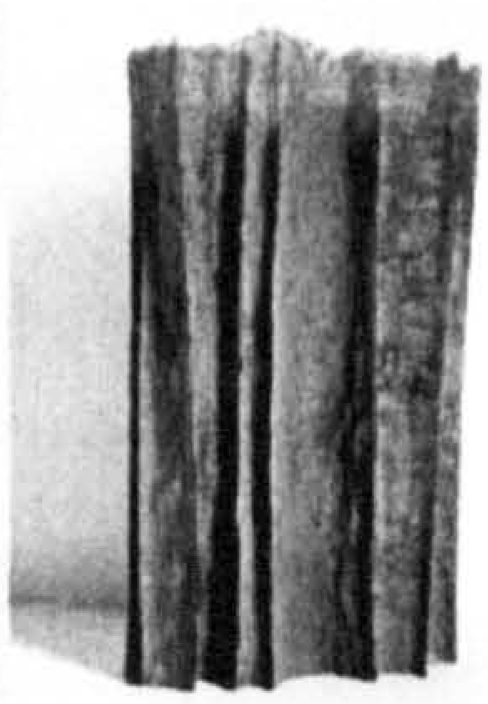
234 A, B, C Architectural textile membrane, mock-up. Nonwovens, adhesive web, heat press.

235 A, B An early stage of the object PULSATING OBJECT. Architectural textile membrane, mock-up. Fine nonwoven, adhesive film.

236 A, B, C An early stage of the object PULSATING OBJECT. Mock-up: nonwoven, adhesive film, thermochromic ink.

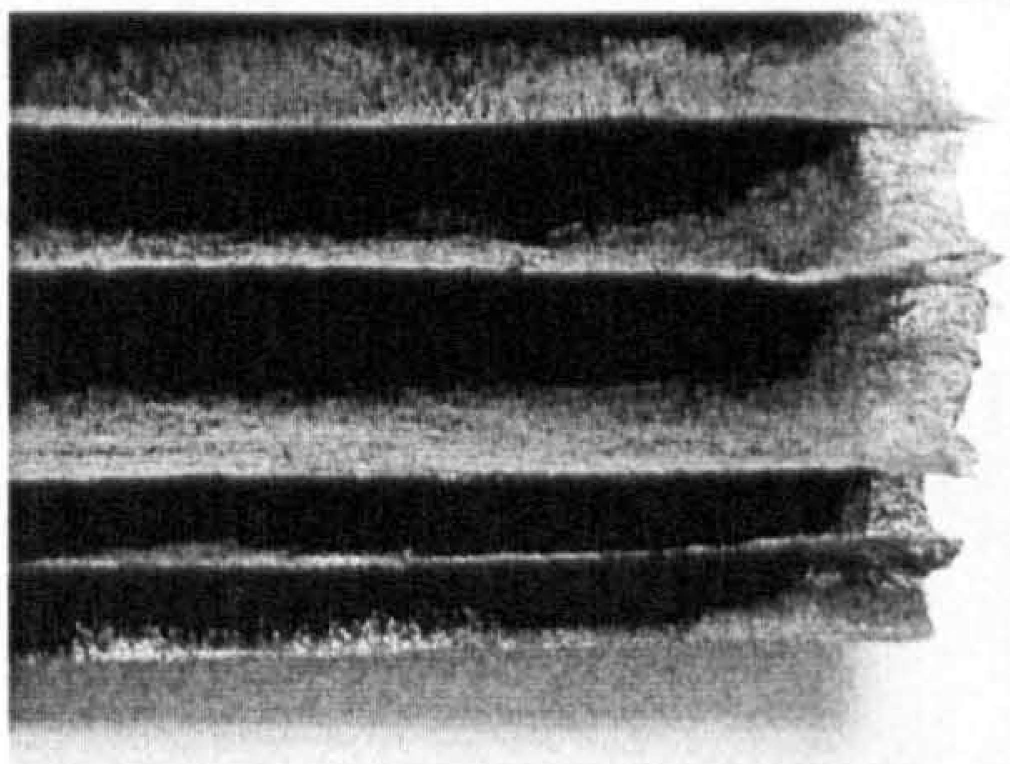


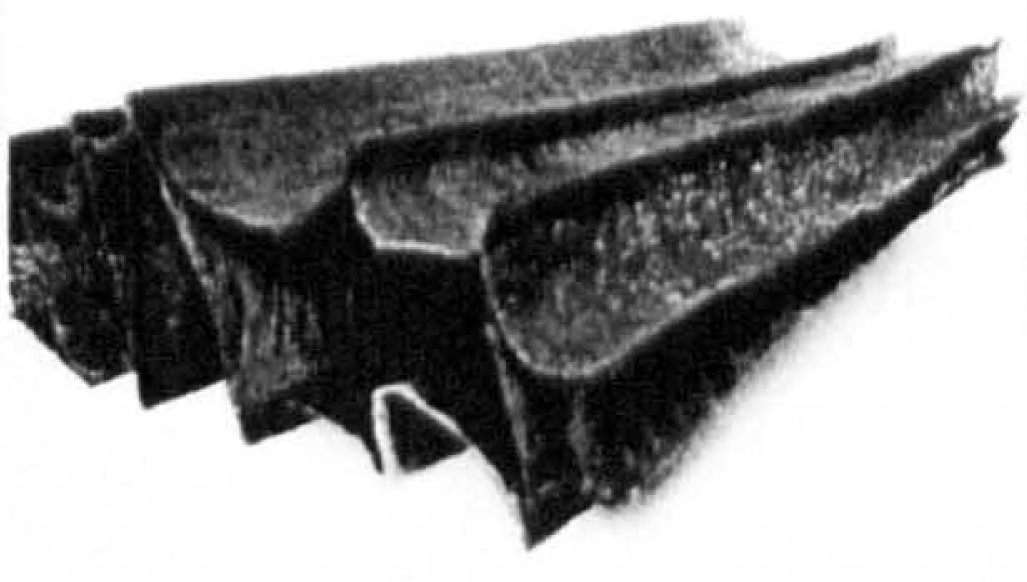




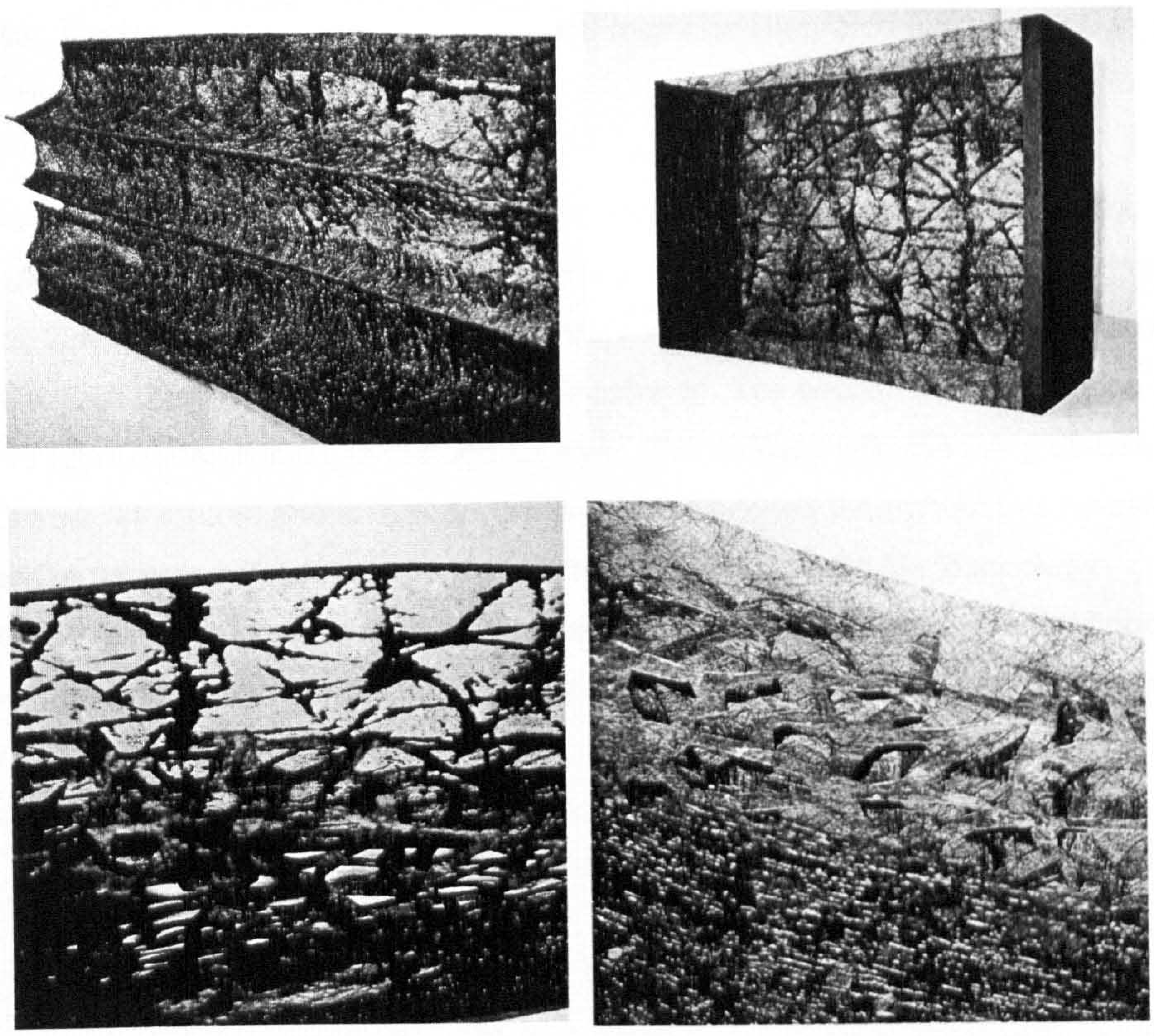
235 A, B

236 A





236 B, C



237 A, B, C, D Experiments with structural aspects of skin tissue. Liquid Crystal inks and nonwovens.

11.4.3 SUMMARY

During my empirical and technical experiments I explored the properties and aesthetics of industrial textile materials in combination with traditional ones and non-textile materials. I also investigated the decorative and tactile potential of both smart and traditional textile technologies and how these might be integrated into new design solutions.

The textile prints, together with other fabric surface technologies such as coating, lamination or impregnation, literally provide a protective skin-like layer of epidermal tissue. These finishes create certain aesthetics in addition to their technical functions as described throughout Chapter 10 and Chapter 11. The second layer, being the treated base material itself, is the dermal layer. The analogy with the living dermis, skin layers, structures and its functions has been employed throughout this research under the aspects of 'skin topography', 'skin architecture' and 'skin technology'. Ultimately, this led my practice to the 'interactive and functional skin' where all above named aspects came together, forming the materialisation of the SKIN STORIES concept as featured in the following Chapter.

CHAPTER 12 ::

PRACTICE STEP III – DESIGN ARTWORKS

12 PRACTICE STEP III :: DESIGN ARTWORKS

A practical objective of this research was to bring all selected and tested technologies together in order to create new, responsive and interactive textiles, which met the concept of 2nd and 3rd skin. As a result of my experiments in the textile studios a number of design prototypes were produced for the final PhD exhibition. Since whatever works at small scale may not be feasible at a larger scale, serious consideration was given to product development issues. While my previous expertise in producing large scale textile pieces was very valuable, issues of engineering and electronics were completely new to me. Problems related to the engineering of simple electronics, essential to my textiles in order to support the integrated analogue systems, such as special time relays and switches occurred. One of my first large scale prototypes caught fire in the middle of an exhibition due to an overheated heater that apparently malfunctioned. Thanks to practical support and advise provided by Colin Dawson, my external advisor, I was able to overcome these technical and engineering problems.

This Chapter describes each design artwork separately giving details on the conceptual and technological background, processes employed, aesthetic considerations, as well as on the biological skin analogy used for the work. It was not possible to realise all the ideas in a large scale due to limits of time and engineering support, therefore it is essential to view these prototypes together with the original work samples in the Textiles File (Appendix D).

12.1 MEMBRANES

Object Dimensions: 15 pieces, 0,6 m x 2,5 m each

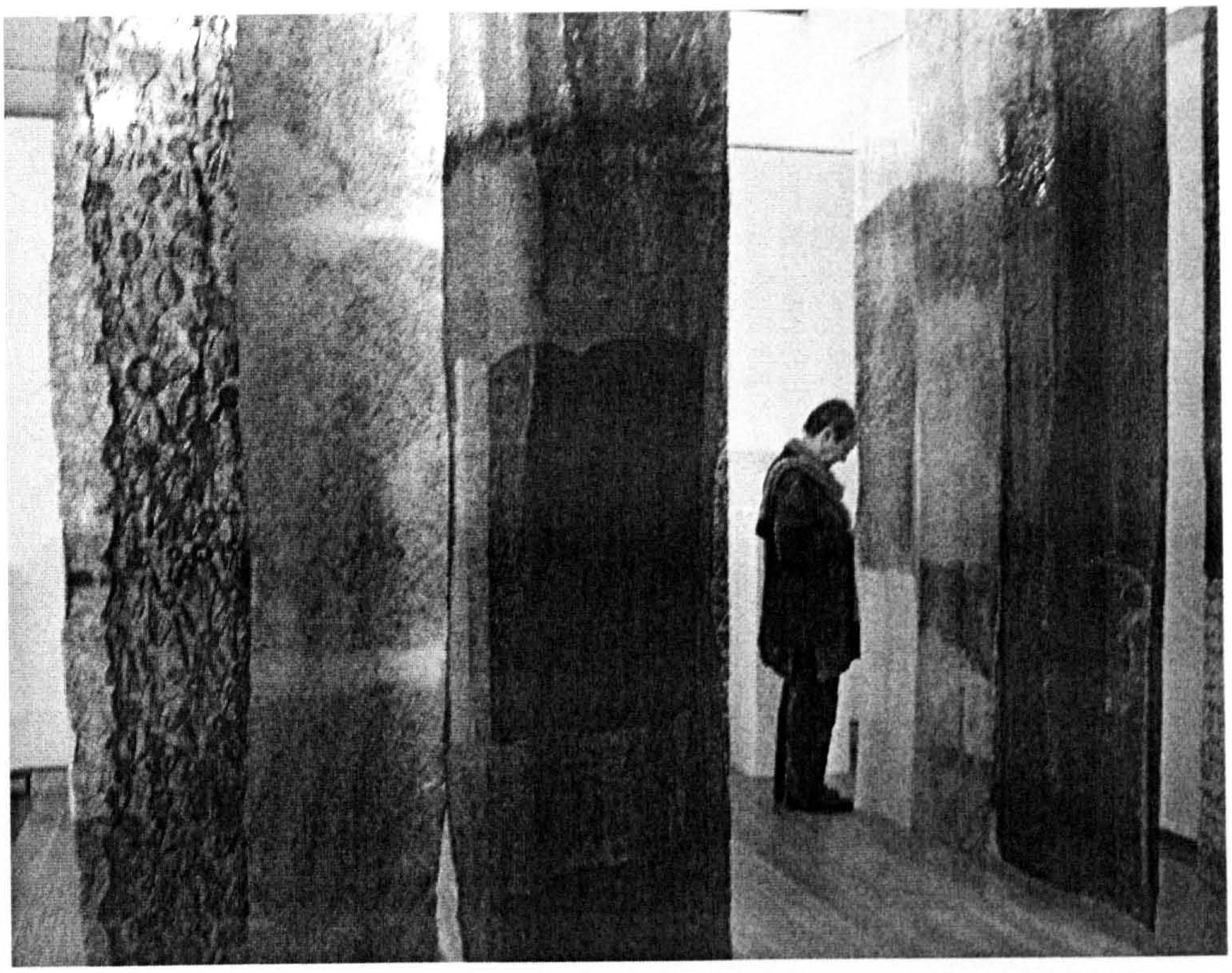
Connectivity & Contribution to New Knowledge:

This mixed-media textile installation refers to skin as a complex genetic and social display. The MEMBRANES, blood- and skin-tone surfaces, at first seem surrealistic landscapes depicting alien territories. In fact these represent microscopic passages in the human body, sometimes enlarged to incredible proportions and/or abstracted using methods of fragmentation, disassembling and reassembling.

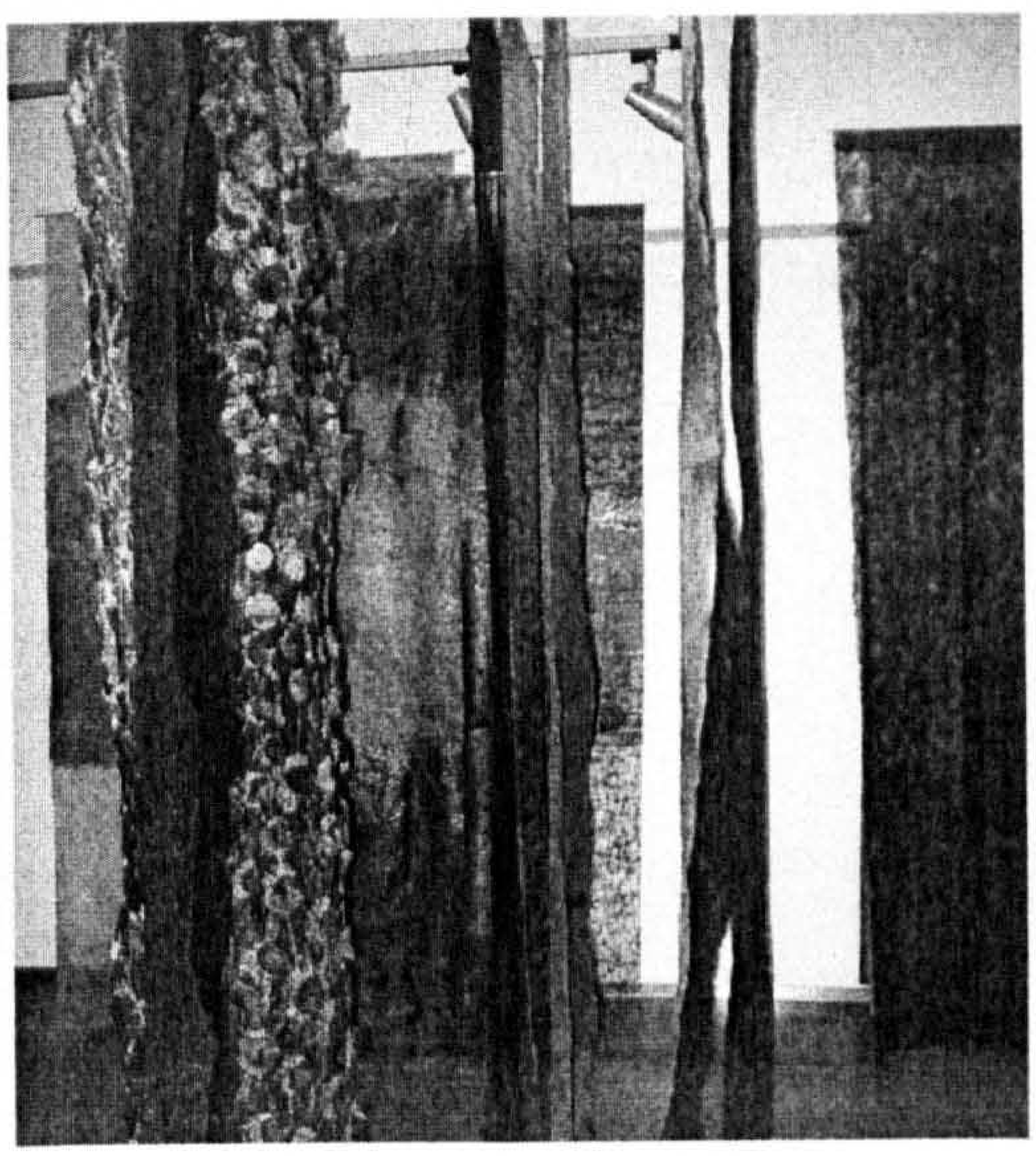
The work comments on the scientific notion of the biological skin as a multi-layered organ consisting of epidermis, dermis and subcutis by using scientific representations of skin such as micrographs for my main point of inquiry and inspiration. I used various mixed-media techniques and appropriate fabrics to mimic the amazing structures and patterns revealed by the microscope. This work also makes reference to skin as an embodiment of identity and memory, to skin as a mirror of the physical and mental state and an indicator of individual social status. Indirectly it also reflects developments in medicine and science due to the use of the dermatological research methods and biomedical equipment during my investigations, while remaining a personal artistic interpretation of the epidermis and the underlying interiors of the body.

For the creation of this installation various materials were used: industrial filter nonwovens, silks, silicone, plastic foils, adhesive mono-filament webs, metallic effect foils, various print and dye pigments, including fluorescent and puff pigments, flock transfers and transfer films. The techniques employed were: pigment screen printing, discharge printing, heat transfer printing, dyeing, layering, bonding, 3-D moulding, lamination and coating.

When making this work I was particularly interested in establishing a link between the formal and obvious information derived from scientific imagery of the skin tissue (shapes, colours) and my personal emotional responses to different types of skins related to the various physical and emotional states of an individual. Beyond its mere biological constitution I was concerned with the skin as a medium for communication of identity in the context of our social interactions.



238, 239 MEMBRANES, 2003.



240 Textile No 1. Coloured silicone, household foil.

241 Skin analogy used for the textile piece.

240, 241

Body surfaces can be smooth, beautiful, dry, rough, warm, attractive, distressed, alien, dear, soft, cool, familiar, smelly, aroused, repulsive, tired – all these often being based on our emotional perception of a certain person beyond the visible qualities, which often are signifiers of moral qualities that we identify with a certain person. Therefore, my textiles also reflect my own emotional perception of each individual (skin donor) featured in my work in addition to certain biological characteristics based on their magnified skin tissue patterns, which typically are very similar to all mammals in general.

The sometimes overwhelming physical quality of the mixed-media MEMBRANES attract and repulse the viewer - at the same time they are sensuous and they are clinical due to their biomedical origin. This sensation is emphasised by the use of intense fleshy colours, as well as silicone and latex – the materials apparently inheriting skin-like qualities and carrying compound cultural references. The translucency of silicone was coupled with softly 'wrinkled' foils and the obvious skin-like qualities of latex - with different base substrates in order to achieve the individual characteristics of each textile piece by combining textile and non-textile materials. Various finishings and multi-layered constructions employing natural materials (silks, cottons) in contrast to synthetic ones (adhesive films, effect foils) were also used to symbolically address the synergy between nature and technology within the context of a contemporary body.

For example in textile No 1 I have been concerned with the fleshy aspect of skin tissue as if it was turned inside out. Metaphorically it leads us to think of highlighted feelings that are not controlled by our mind. The heavy-weight fabric length made from layers of dark-red-tinted silicone refers to the underlying body itself. The fabric, supported with a thin membrane of a foil, which carries delicately sculpted wrinkles and folds embossed during the thickening process of the first layer of silicone, represents the irregular landscapes of skin surface. The work piece provokes subconscious sensations by making references to the carnal body admitting the sexual content of skin.

The actual production of this piece involved many sessions, literally embracing the aspect of time in the body of work while waiting for the actual layer of silicone to harden. The material and the process added something that is much more physical to the work piece compered to my other textiles. Here the traces of time are actually made visible as the liquidy silicone was mutating during the process of hardening as if it were alive. Upon thickening it was releasing air bubbles that were captured during the process of mixing the silicone oil with a hardening agent and therefore, created occasional deformations into the generally smooth surface. This specific material property was used to comment on the issues of beauty and imperfection as the little 'errors' are what makes us different from each other and therefore so human.

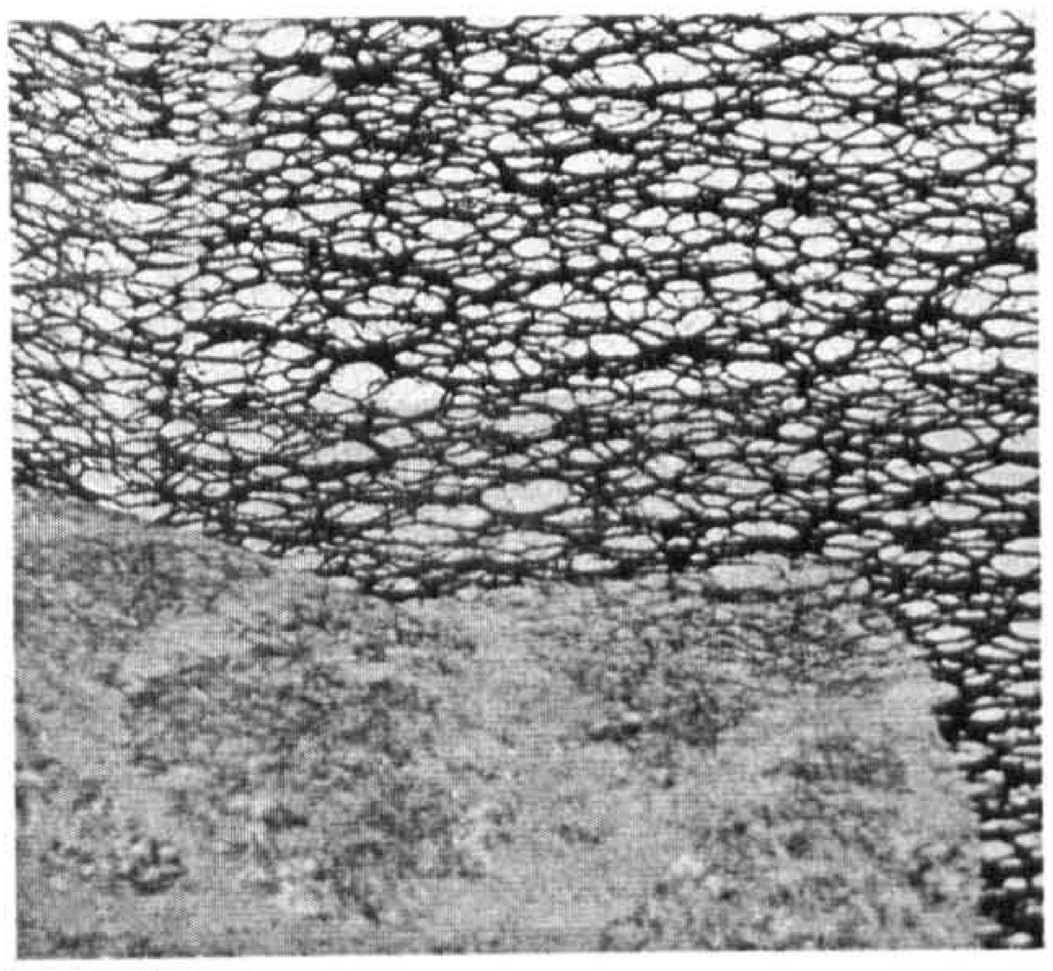
Typically, even after hardening, the silicone surface is slightly sticky. Talcum powder in combination with self-adhesive matt metallic foils were used in order to achieve proper surface finishing. The resultant two lengths of fabric had a particularly distinctive tactile quality that I have not seen elsewhere.

A range of spun-laid nonwovens were used for production of installation due to their reference to the basic structural properties of skin tissue in addition to their various pleasing visual and tactile qualities. For example, these were used in the textile No 2 that was exploring the vascular structure and the soft nature of skin. In this piece the body's surface is addressed more as a series of fragile layers that reveal and conceal the underlying body interiors. The various segments smoothly shift from extremely thin, semitransparent membranes ,into thicker multi-layered fields that refer to both the intimate organisation of various skin tissues, as well as to the idea of body and skin as carriers of complex cultural layers, codes and identities.

In order to facilitate these aspects in a textile piece I used a thin technical nonwoven that was seamlessly bonded with layers of thicker fleece and then, all together, transfer printed using disperse inks. The abstract landscapes in skin-like hues painted with this ink become fully absorbed by polyester fibres without changing the soft fabric properties. Furthermore, the thermo-fixing technique was used to add layers of thin capillary network patterns, creatively applying technical adhesive monofilament SPUNFAB® webs that come in various densities and structures. The properties of these webs allow them to be bond simultaneously with the background substrate and metallic foils creating shimmering surface that resembles the fragile patterns of the vascular network.

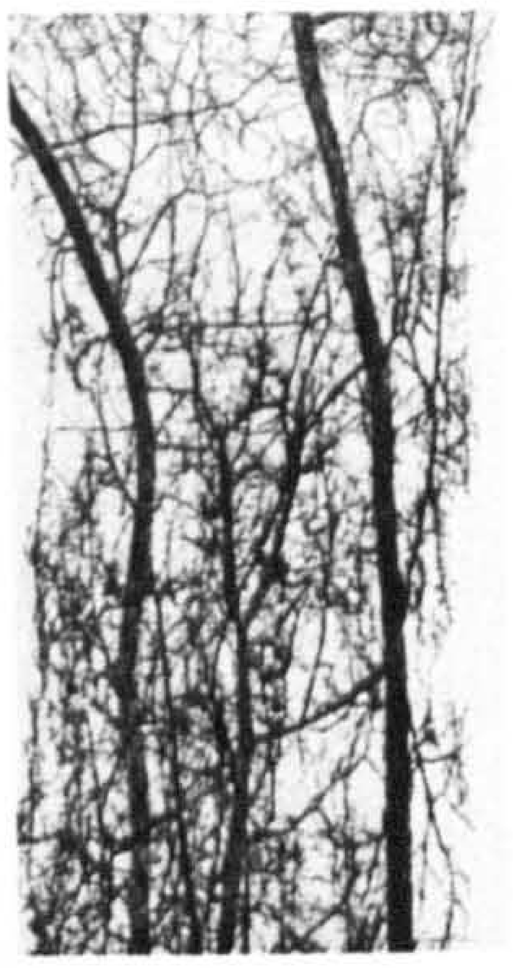
The SPUNFAB® industrial adhesive webs that have excellent bond strength values, no full-surface adhesion which therefore adds openness of the structure, excellent permeability values and high elasticity have not yet been used in the textiles design field for purposes of surface decoration. In my work this material, organically joined with polyesters with a help of heat transfer press, allowed me to achieve multi-layered fabric constructions and sophisticated surface design patterns with a soft handle. Additionally, some parts of the textile were screen printed with images of skin surface patterns, adding another layer to the MEMBRANE.

In example No 3 I was concerned with the qualities of an older skin. With time skin becomes dryer and loses its elasticity. To address this issue the natural tendency of crepe silk to shrink, when coming in contact with water, was used to create dimensional surfaces that mimic the uneven and slightly loose skin-like properties characteristic



242 Textile No 2.
Nonwovens, adhesive web, metallic foil.

243 Capillaries network.
Skin analogy used for the textile piece.



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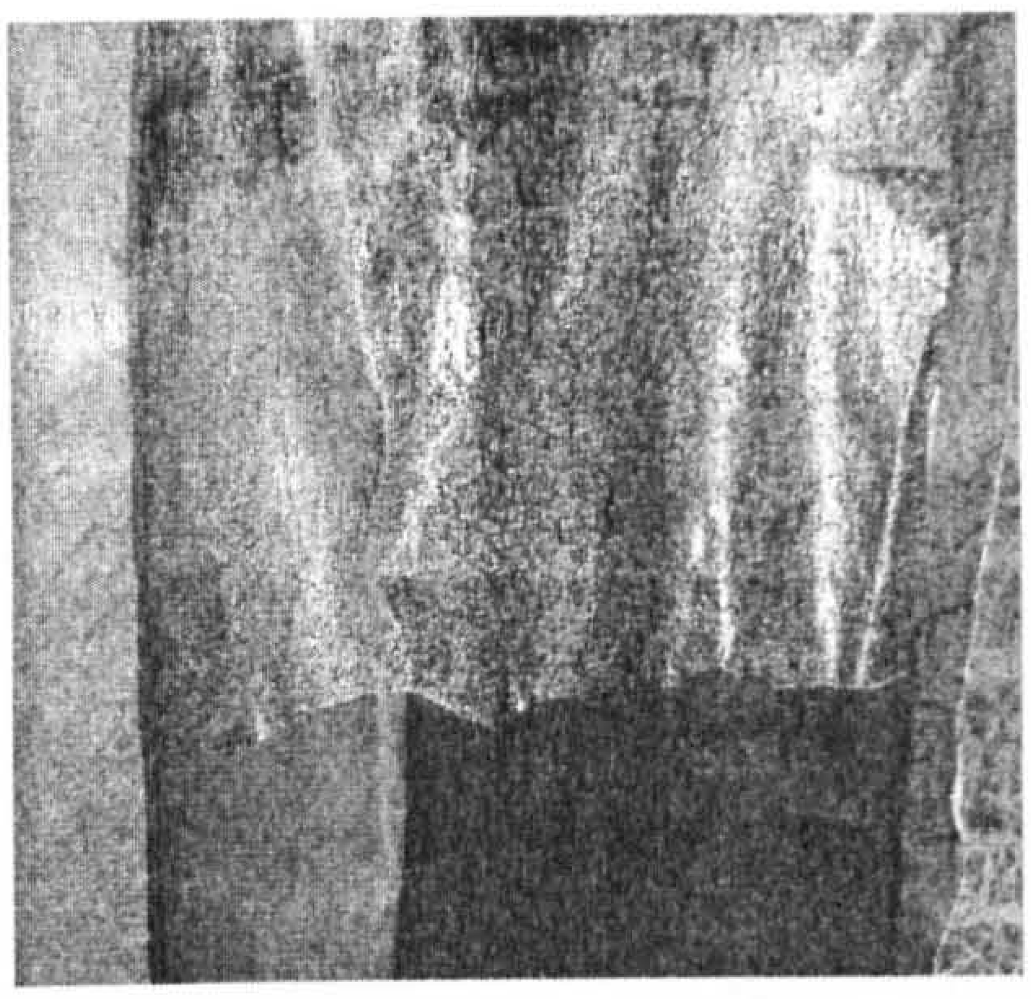
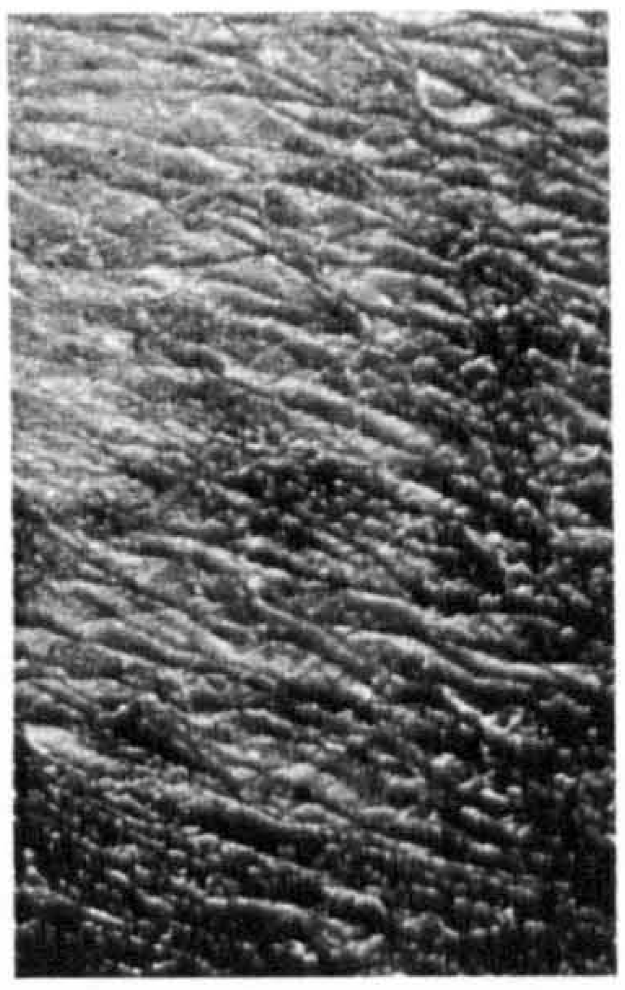
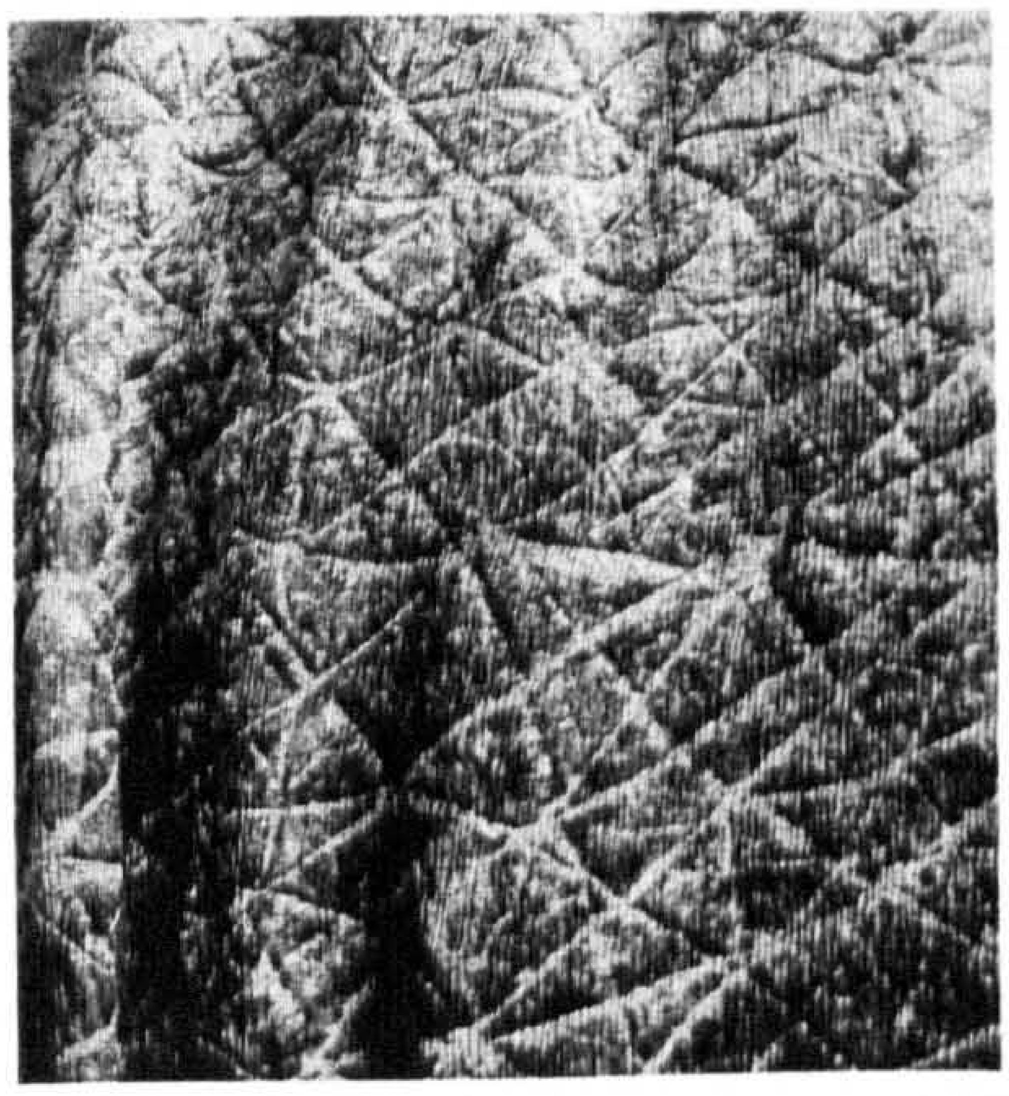




244 Textile No 3.
Crepe silk, laminates, discharge printing.

245 Old skin.
Skin analogy used for the creation of the textile piece.

244, 245



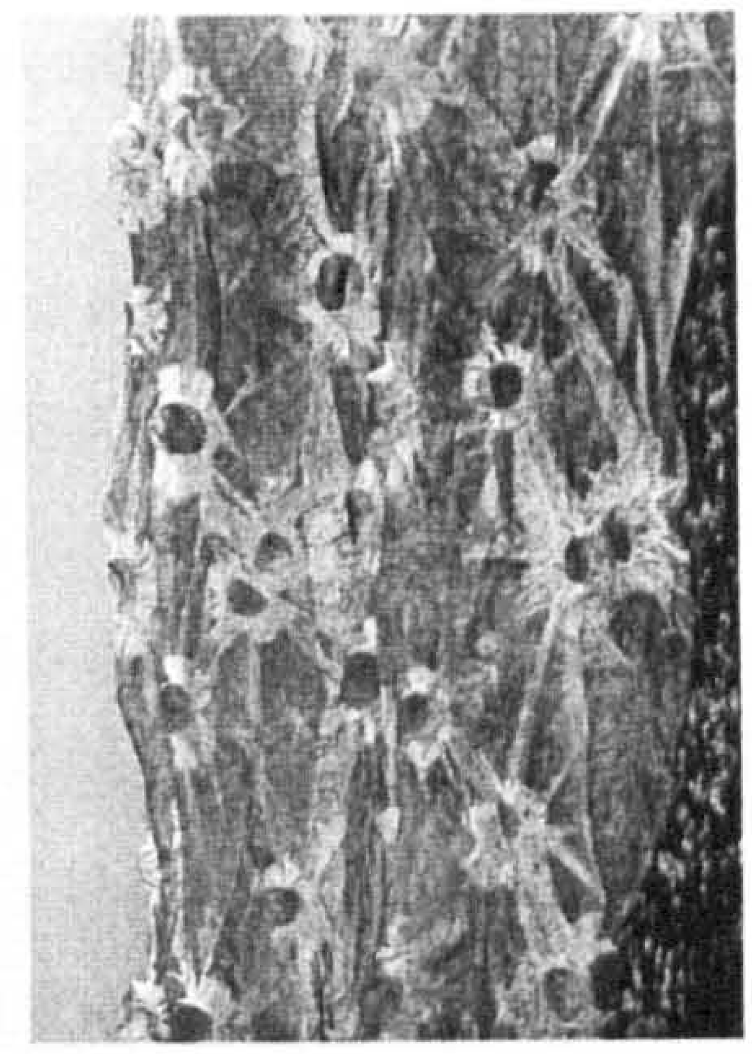
246 Textile No 4.
Crepe silk, digital printing.

247 Crisp skin.
Skin analogy used for the creation of the textile piece.

246, 247

248 Textile No 5.
Nonwonen, disperse transfer inks, heat transfer press.

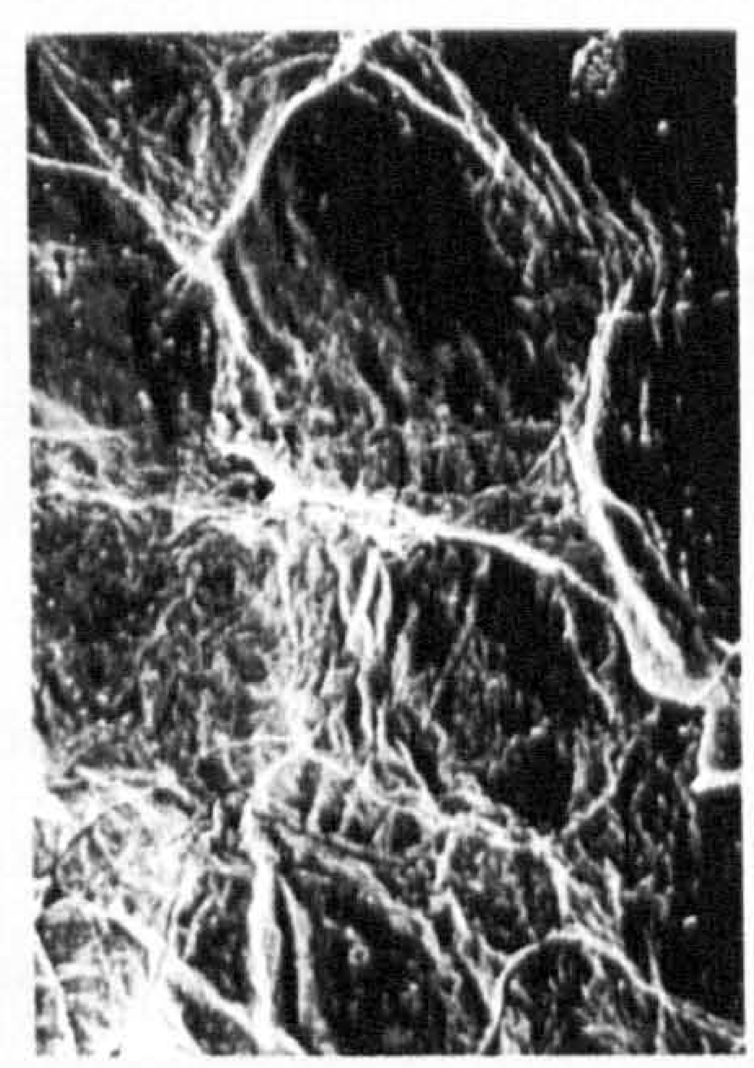
249 Dead skin cells.
Scanning electron micrograph.
Skin analogy used for the creation of the textile piece.



248, 249

250 Textile No 6.
Nonwonen, disperse transfer inks, heat transfer press.

251 Black skin.
Scanning electron micrograph.
Skin analogy used for the creation of the textile piece.



250, 251

of an elderly skin. A skin surface image featuring a network of furrows, obtained from an elderly donor, was used for a screen printing pattern employing discharge inks. Prior to printing the image was digitally manipulated, using the process of 'skeletization', in order to obtain a clear black and white rendering of the initial biological input, leaving no mid-tones, as appropriate for screen making purposes. Then a weak discharge solution was used so that delicate skin patterns on dark silk could be achieved.

In some areas the fabric was covered with protective laminates – thin thermo-plastic foils. The smooth, synthetic and shiny surface of plastics in contrast to the softly textured silk, metaphorically, refer to the artificial support applied in a context of our society to keep the desired illusion of youth despite the inevitable course of time.

Another piece of work, the textile No 4, explores the crisp-like aspects of skin. In order to achieve the wanted haptic qualities another length of crepe silk was used. After washing and drying it was coated with a special MANUTEX-based stiffening solution (water 3 : MANUTEX 6 : urea 1) and allowed to dry. This transforms the thin and soft silk into a fragile parchment-like piece. Prior to this treatment the fabric was ink-jet printed with a slightly enlarged pattern of a healthy skin surface that repeats across a large area.

In this work low magnification of the epidermal structure as well as an overall print and natural beige colour scheme used as designing tools, provide a naturalistic representation of skin. The skin-like quality of the base silk material is highlighted with the illusion of wrinkles within a overly regular repeat that enables the surface to appear extremely three-dimensional and alive. On the other hand the regular repeat adds an industrial expression, perhaps, referring to nature as an immortal tailor. This work is one of the most realistic representations of skin tissue in my entire SKIN STORIES collection allowing the viewer to recognise the skin patterns that are very familiar to each of us. The work also utilises the 3-D crepe silk qualities in combination with a stiffening solution, that adds to tactile and visual qualities of the fabric.

The constant dying of our epidermis – the continuous process of shedding off skin cells has to do with the constant regeneration of our body. As seen in Figure 248, in textile No 5 I am exploring the very surface of the epidermis which consists of a layer of microscopic dead cells. Only when studying skin under an electron microscope it is possible to see the actual arrangement of the outer skin layer. However, those cells which were about to fall off the actual skin specimen at the moment of preparation have been already removed during this process. Therefore, it is virtually impossible to watch the constant movement happening on our body's surface but it is possible to envision it when observing the enlarged skin landscapes and its structures.

As a response to the biological information on this issue, I created a length of sculptural fabric that mimics the shapes and patterns of keratinised skin cells, by employing a time consuming process of individually wrapping and fixing small paper discs into a dyed polyester nonwoven to achieve the three-dimensional patterns. Then the prepared fabric was passed through a heat transfer press several times, applying disperse dyes, in order to acquire various hues of beige, orange and reds. Due to the thermo-plastic properties of polyester it is capable of obtaining permanent sculptural patterns in response to heat and pressure, therefore, when finally untying and removing the paper discs, a piece of soft and three-dimensionally moulded fabric was the result. The places in the fabric where the small discs were incorporated during the heat transfer process, now have transmuted into a series of flat skin cells that are caught at the moment of departing the surface.

Skin tones range from pale whites to blacks in brown and blue shades. In order to address the ethnical skin issue, as well as to balance the red-orange-beige colour scheme dominating my SKIN STORIES collection, I introduced some subtle black shades into my work as seen in the textile example No 6. In this piece I was still continuing to concentrate on the three-dimensional aspects of skin tissue and its flat cell patterns that are typically the same in all types of human skin, not depending on their ethnic origin.

A length of an industrial nonwoven with a skin-like fibre arrangement was firstly dyed in dark beige tones, then, similarly to the previously described textile No 5, prepared using paper discs and the shibori-like wrapping method, and finally passed through a heat transfer press to obtain the final layer of a black tint. The polyester nonwoven chosen was made of a firm fibre structure referring to the thicker construction of black skin that has to prevent the body from harmful UV light.

When unwrapped, the fabric unfolds in a refined pattern of black coloured epidermal cells, which become even more highlighted due to the beige base under each cell shape, created by the paper circle that acted as a reserve. The semitransparent structure and organic fibre arrangement of the nonwoven add to the aesthetic qualities of the new textile and light, shining through it, creates soft shadows emphasising the sculptural aspects of the work.

The textile pieces produced have a potential to be used for applications within interiors as space dividers, decorative textile panels, curtains, wall coverings as well as for applications in fashion and clothing depending on their aesthetic, tactile and functional qualities. Potential developments for the MEMBRANES include focus on more functional surfaces, which might explore the aspects of protection that provide electromagnetic shielding, anti-static properties and anti-bacterial properties. These textiles would be based on my current experiments as shown in the Textile File (Appendix D).

12.2 PULSATING OBJECT

Object dimensions: 1,7 m x 1,2 m x 1,0 m

Connectivity & Contribution to New Knowledge:
The inspiration for the PULSATING OBJECT is derived from biology and our bodily responses to internal and external stimuli. For instance: change of skin colour in response to stimuli coming from our nervous system, or changes in our blood circulation as a reaction to excessive heat. The analogy used is that of human skin reactions to physical and psychological stimuli - skin as a sensor and biochemical mechanism.

PULSATING OBJECT is an interactive heat-sensitive textile installation which responds to changing environmental conditions. The textile object treated with thermochromic ink functions as a reversible indicator of fluctuating room temperatures, depending on the ambient or external heat by changing colour. The colourchange takes place in pulsating wave-like movements across the whole object so that it becomes virtually 'alive'. For the creation of this object chromatic inks with an activation temperature at 40°C, industrial nonwovens, metal pipes, household heaters and timers have been used.

PULSATING OBJECT has originated from my experiments addressing the three-dimensionality of magnified skin structures described in Section 11.4.2.1. Being inspired by the scientific images obtained applying the 'shadowing principle' to a negative impression of a skin specimen (see 08.4), used by dermatologists to examine the character and depth of furrows, I first produced a sculptural prototype object at an A4 size. This object was put together with multiple vertical segments that were joined with an adhesive film in an organically formed multi-angular shape (Prototype No 1). For the purposes of stability, this membrane, which is linked together at both vertical sides, was supported with several vertical intersections. The textile material used for the prototype is a spunlaid nonwoven with an organic fibre arrangement that in my work typically stands for the elastin and collagen fibre structure forming the skin tissue.

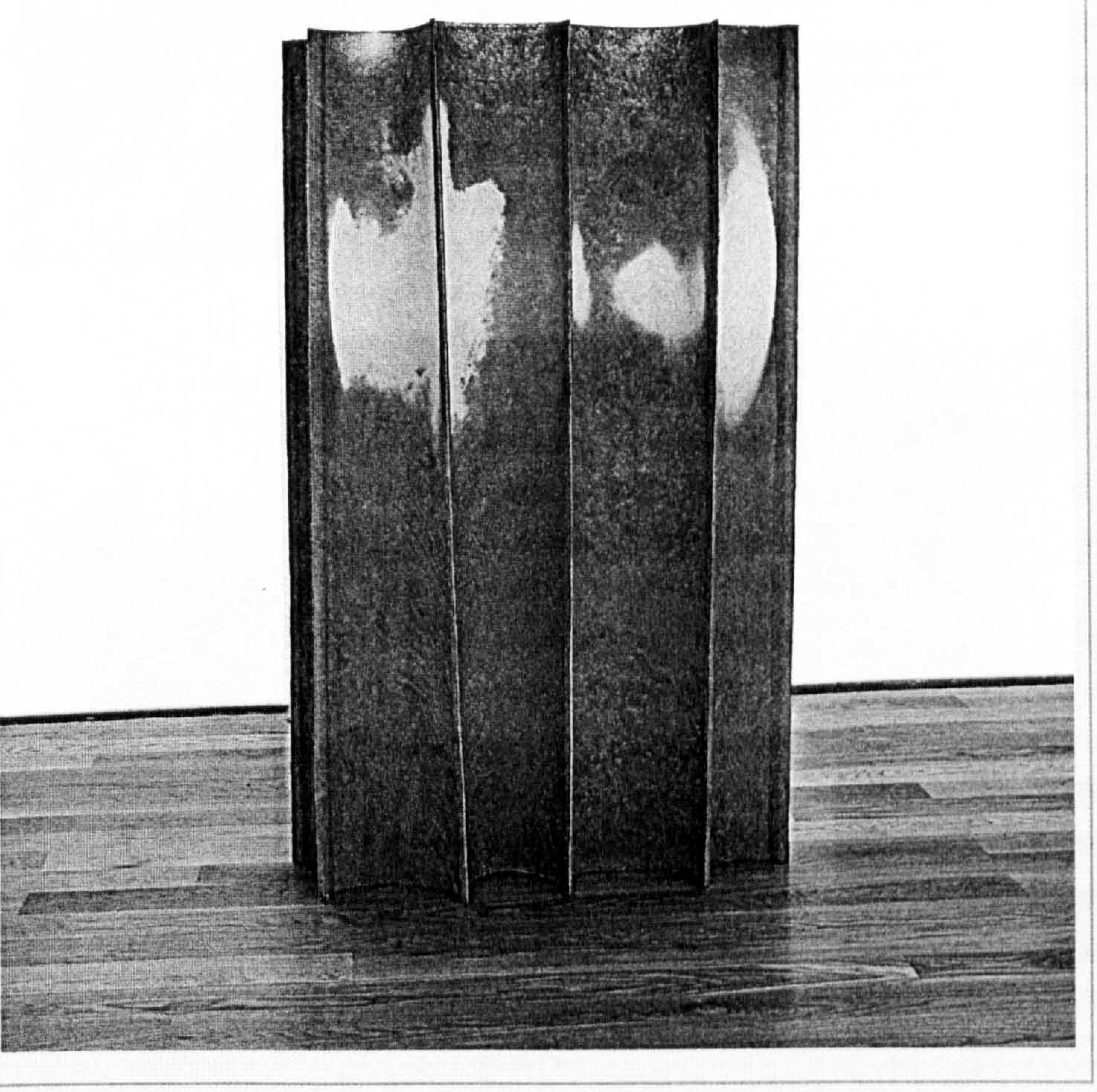
In order to 'animate' the object I experimented with thermochromic printing inks, applying them onto nonwoven object walls (Prototype No 2). These inks change colour in reaction to heat and therefore they were selected as one of my designing tools to sustain an interactive design. My intent was to achieve an illusion of a living body within the closed membrane, to establish the analogy with the living skin tissue. From a designer's point of view I was particularly interested in employing a natural heat source for the control of the colourchange processes, instead of a possible 'smarter' approach incorporating electronics into the membrane of the object. I decided that in this case a stroke of warm air is a much more poetic way of expressing the bodily heat or outer stimuli than use of high-tech systems.

Firstly, simple tests to examine colourchange processes were carried out using a hair dryer. The heat was applied from outside the object and, due to the small size of the prototype, it was easy to achieve a rapid response to the source of the heat. The reverse reaction back to its initial colour was much slower for two reasons:

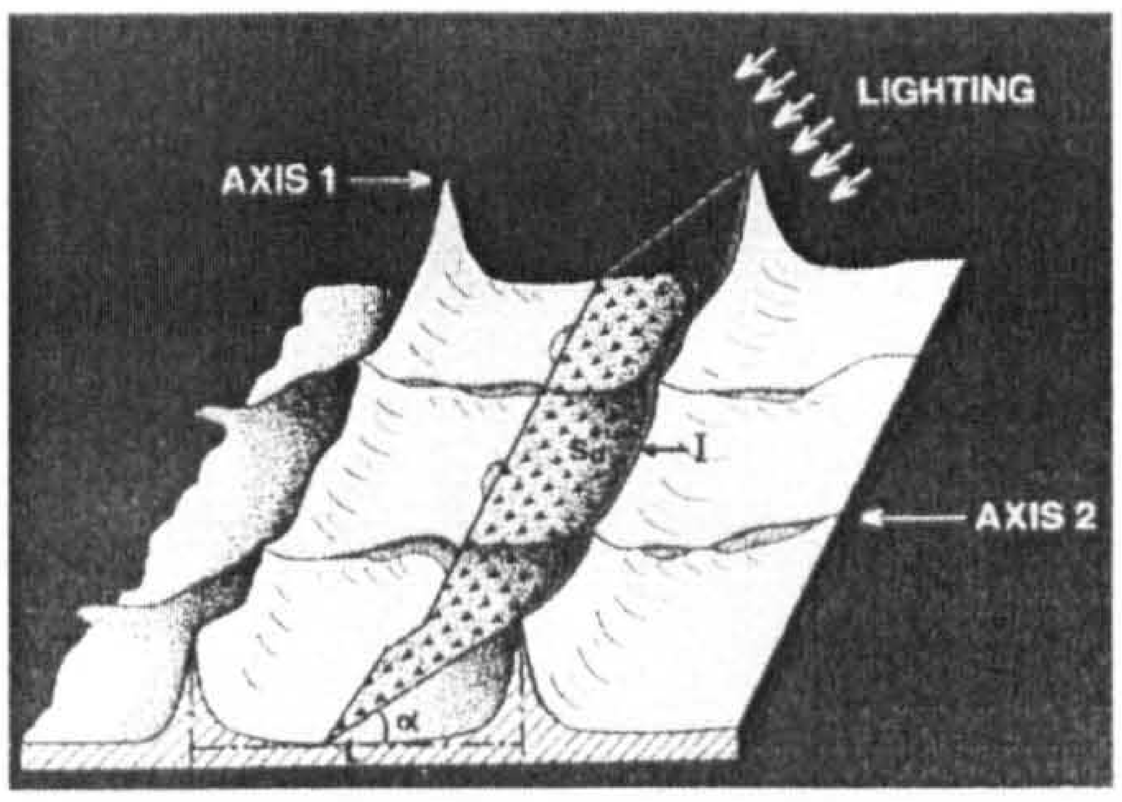
- the activation temperature of the thermochromic inks used for this prototype was industrially set at 24°C, which automatically indicate that the threshold temperature is at 33°C. This, in combination with warm room temperature (23°C on the day of conducting the tests), naturally increases the textile substrate base temperature
- the typical characteristics of TC inks to react slower to the fall in temperature than to the rise in temperature.

When planing the realisation of the final PULSATING OBJECT prototype aspects of temperature were very important, as it had to be exhibited in two different environments – in Italy during September when the temperature can still hit 40°C and afterwards in London during October/November, when the temperature in buildings is rather low, however heating systems are used. To be sure that no unexpected colourchange will take place due to the influence of ambient temperatures a thermochromic ink with a high activation temperature (40°C, meaning that actual threshold temperature is at 50°C) was chosen. Unfortunately, the consequence of this was that stronger (and more) heating systems had to be employed to achieve the colourchange effect, particularly in relation to the dimensions of the final prototype (1,7 m x 1,2 m x 1,0 m). For this purpose two household hot air blowers were inserted inside the object. These were controlled by conventional timers allowing hot air to blow in a 15 minutes on/off rhythm.

The dimensions of the work had to emphasise the original relationship with the human body, therefore the initial mock-up prototype was blown up to the height of a person. For the realisation of the work a doubled industrial polyamide and polyester mix nonwoven material named Colback WF 120 was used. This had to support the freestanding structure that was reinforced using object-size metal pipes integrated into the edges of the PULSATING OBJECT that refer to giant furrows in a magnified skin tissue.

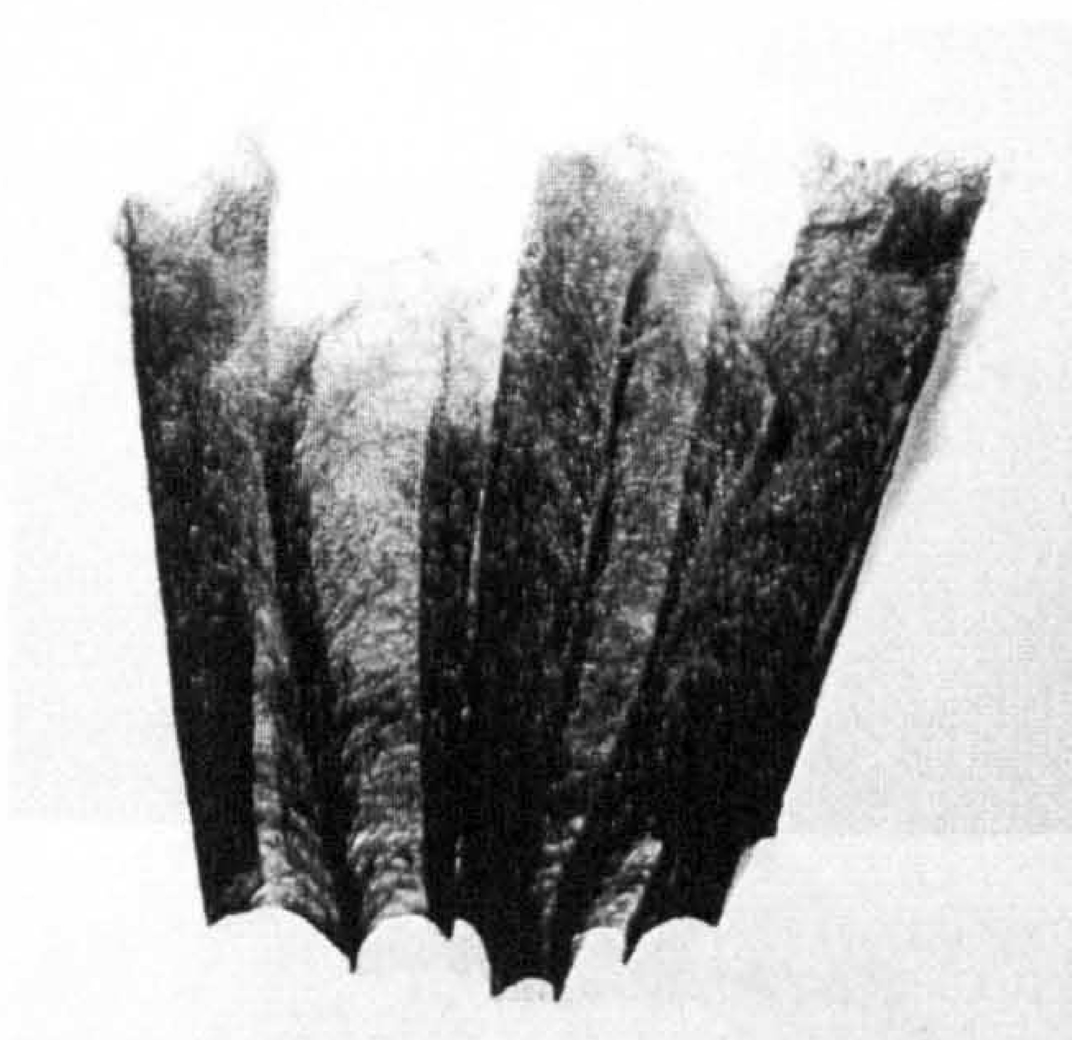


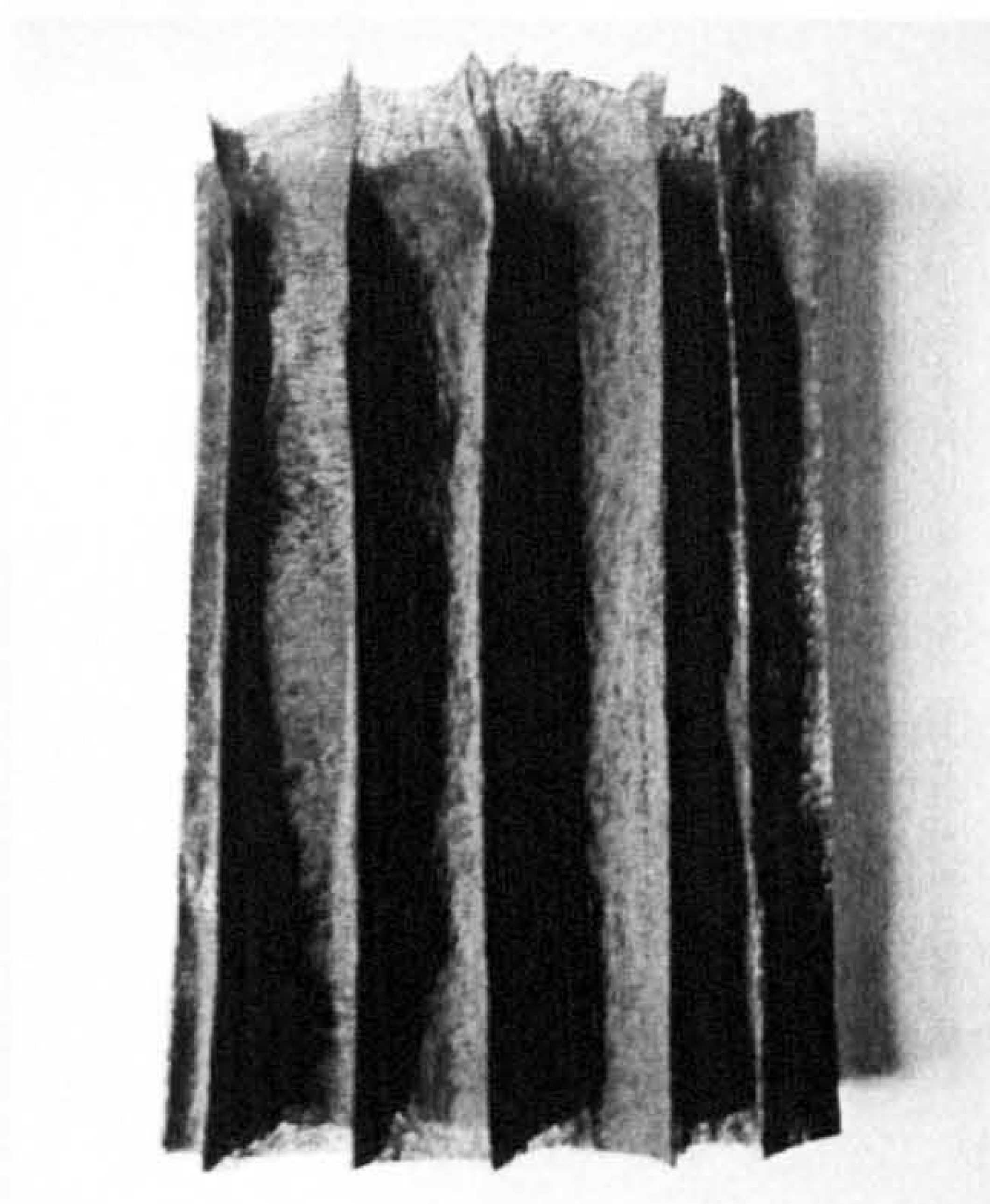
252 PULSATING OBJECT, 2003.



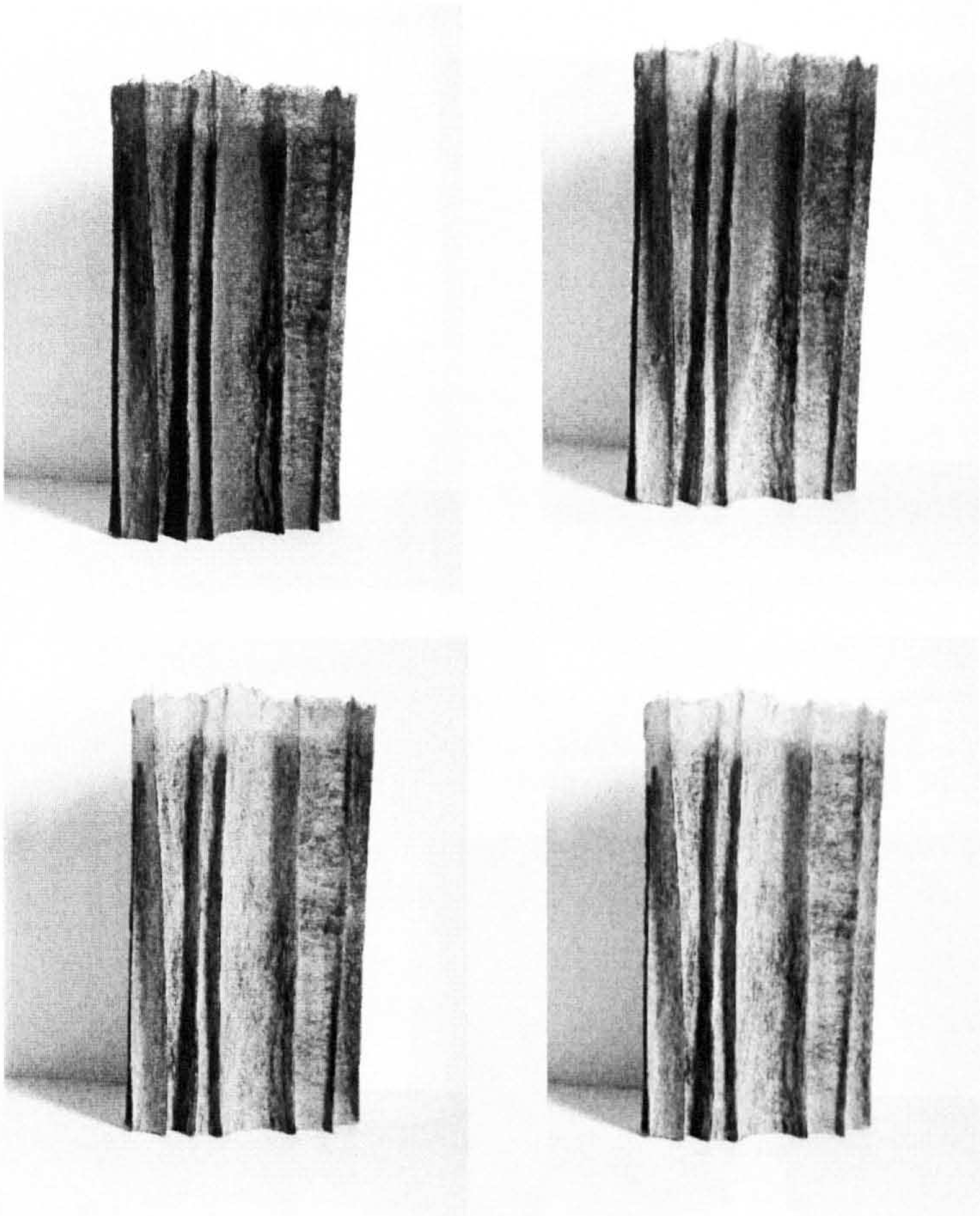
253 The shadowing principle applied on skin surface model.This principle was used for the development of architectural membranes.

254 Pulsating Object. Prototype No 1.
255 Pulsating Object. Prototype No 2.



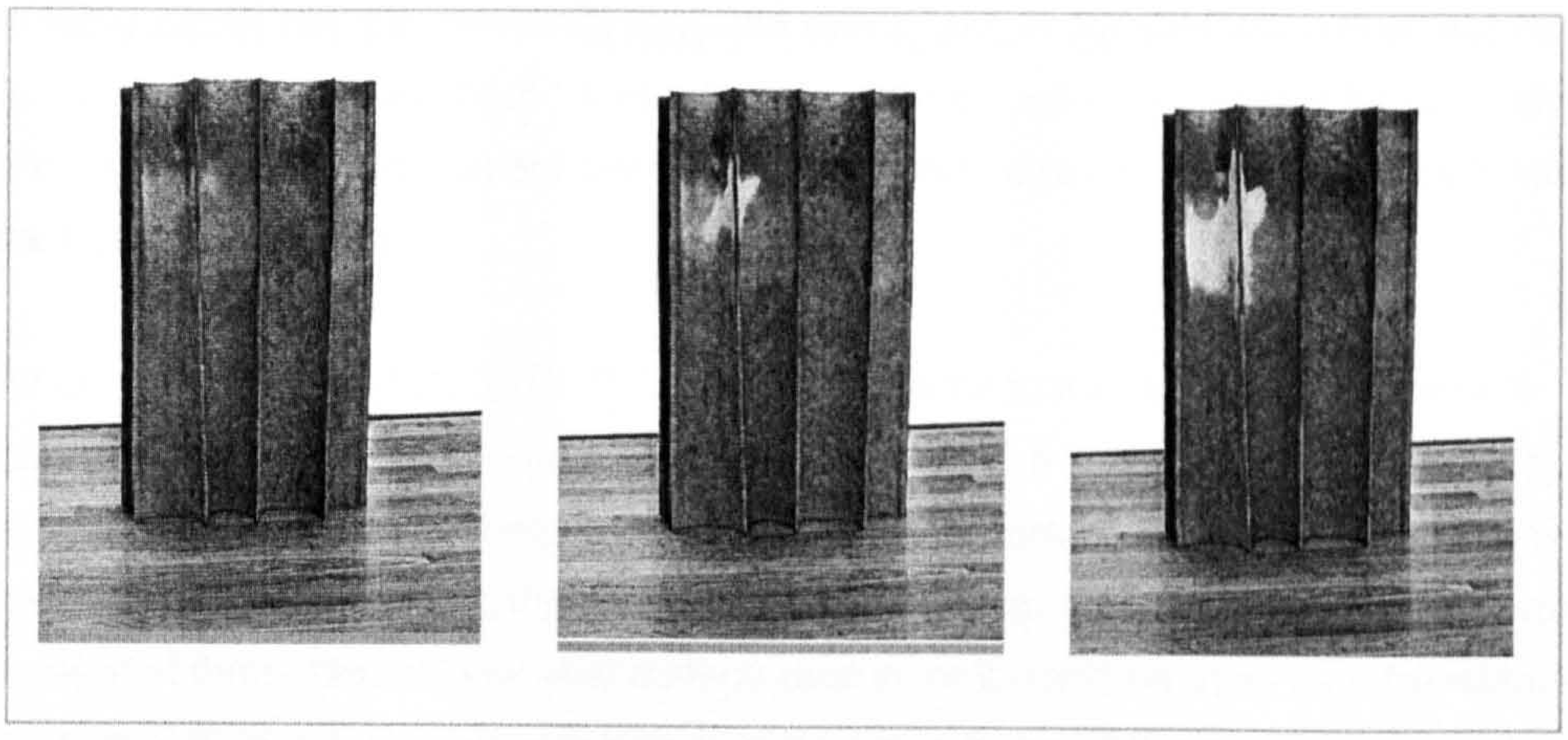


253, 254, 255

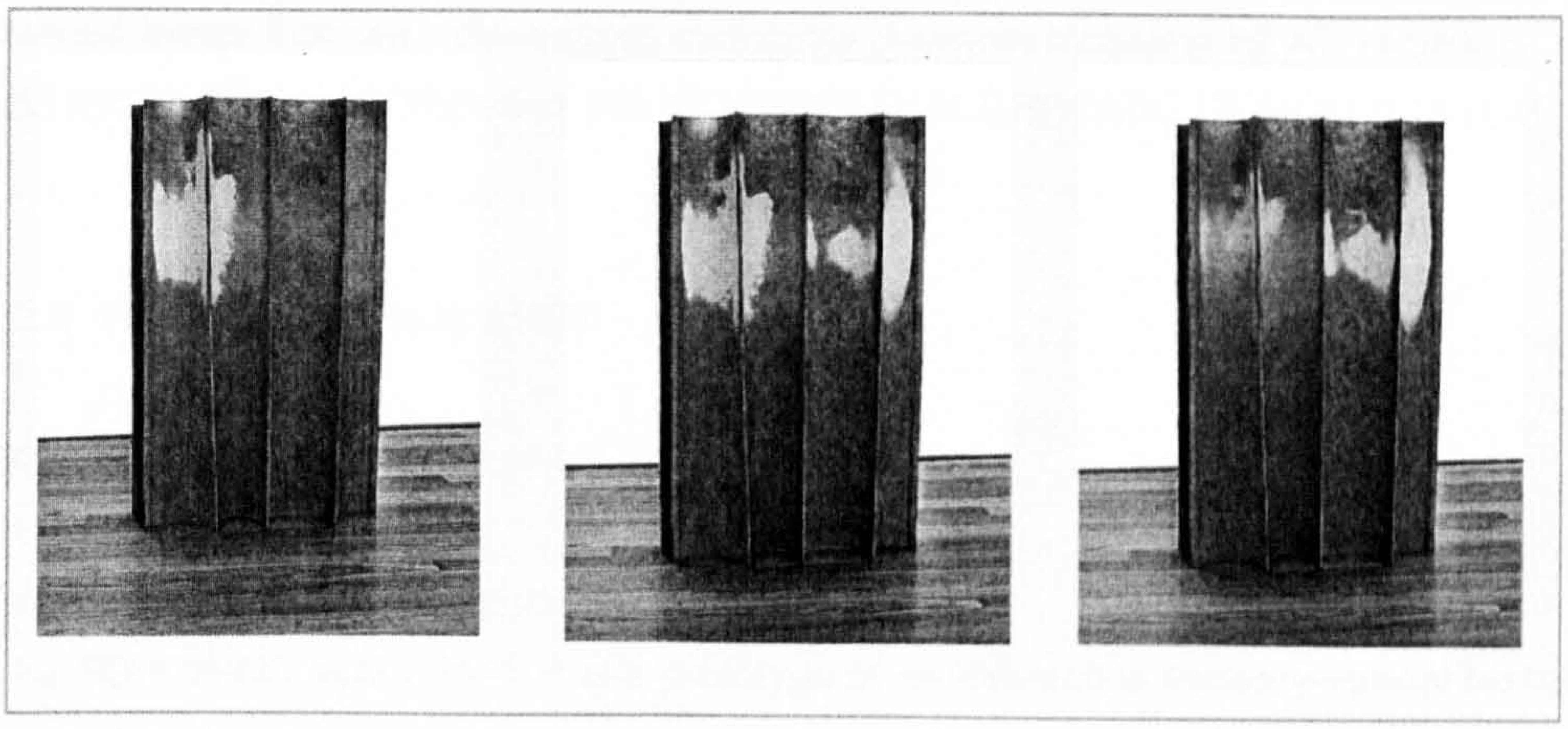


256 A, B, C, D

256 A - D Pulsating Object. Prototype No 2.
Prototype for a heat-sensitive textile installation, which responds to changing environmental conditions. The textile object, treated with therrmochromic ink, functions as a reversible indicator of fluctuating room temperatures, depending on the ambient or external heat, by changing colour. The colourchange takes place in pulsing wave-like movements across the whole object so that it becomes virtually 'alive'.



257 A, B, C The colourchange takes place in pulsating wave-like movements across the object.



257 D,E,F

For the exhibition at the Fashion Space Gallery, London College of Fashion the heaters were attached on 1,5 m high stands, so that they are facing the ground when blowing hot air but are constantly supplied with a cool air for ventilation from above. Additionally, the conventional 15 minutes on/off timers were exchanged for specially pre-programmed ones that are set at 3 minutes on/5 minutes off rhythm, not allowing the heaters to overheat.

When producing the PULSATING OBJECT my intention was to create an anatomical sculpture that oscillates more towards the art work. It fluctuates between textile, sculpture and installation, based on a rationalised pattern of furrows within a magnified skin surface. However, if expanded further, this idea could be applied to a development of three-dimensional wall surface design, or it could be used as a freestanding space divider. For the development of design prototypes it would be necessary to upgrade the low-tech heating system with sensory mechanisms to sustain the physical colourchange plays. Simple electronics could be incorporated to switch between various things that were discovered during my research including HEAT 'N SNIFF, VERSICOLOUR SYSTEM and TCI MULTICOLOUR CHROMIC DESIGN SYSTEM.

12.3 TOUCH-ME WALLPAPER

Object dimensions: 1,8 m x 1,2 m

Connectivity & Contribution to New Knowledge:
The TOUCH-ME WALLPAPER is a prototype of an interactive sensory-appeal textile membrane for wall coverings. It responds to environmental or human heat by changing colour, releasing aromatherapeutic scents and regulating the ambient temperature within a room in order to enhance people's wellbeing. The analogy used for the work is skin as an immunological surveillance and biochemical mechanism. People can interact with the wallpaper by touching it and activating various scents that are embedded into the textile. Additionally, they can create their own bodily patterns, which are temporarily recorded on the wall until they cool and fade away completely. The operating principle of this work is based on the colourchange properties of thermochromic inks, which are applied to the textile membrane. They react like a visual thermometer to changes in levels of heat initiated by human skin warmth.

The TOUCH-ME WALLPAPER prototype explores also the olfactory and filtering potentials of textiles as deodorising, anti-microbial and curative surfaces. Microencapsulation technology, which was used in this work permits the incorporation of aromatic oils and fragrances into textile substrates to enhance the environment by releasing scent. The olfaction can help to reduce stress, enhance relationships and to heal the body and mind. The interactive wall delivers relaxing, vitalising and anti-microbial aromas of various plants as required. The Scratch 'n Sniff technology allows the microcapsules to break in contact with the human body pressure. As discussed in the Section 05.4 – *Skin and Smell*, the concept of integrating aromatherapeutic scents in buildings is not new. For centuries the Arabic world has used fragrances in the mortar for certain mosques.

The areas of the various scents applied on the textile are colour coded making it possible to activate the desired aroma as necessary. The colour pink contains the aroma called 'Ambrosia', the colour ochre stands for 'Summer Flowers' and the violet square carries a 'Eucalyptus' scent. The system of colour codes is introduced for the comfort of people, so that it is easier to recognise the scent using the eye. The scented design patterns are also supposed to be renewable as at some point the microcapsules will all be broken and not be capable of delivering any scent molecules. In this case it would be possible to re-paint the colour coded area xagain with a new solution of encapsulated fragrance.

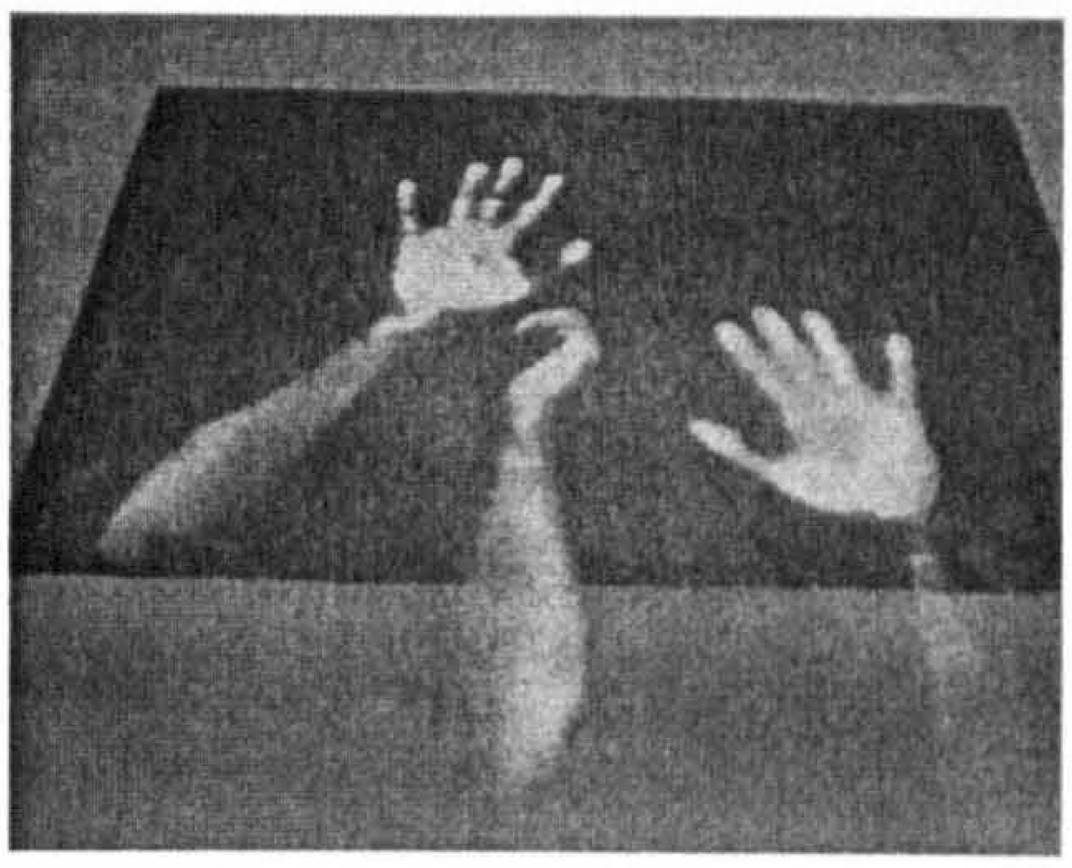
Additionally, the textile wall surface serves as a latent thermoregulator for the environment thanks to Phase Change Material technology integrated within the structure of the base fabric by the manufacturer. This relates to the analogy of skin being a thermoregulator and explores the potential for textiles to become latent heating systems that control room temperature. This appealing idea is still in the development stage by the companies Outlast and Schoeller. I was permitted to use some of the PCM technology fabric for my research work, kindly provided by the Outlast Technologies, in order to contribute to the aesthetics of the fabrics and to demonstrate its properties in a sensory-appeal design concept.

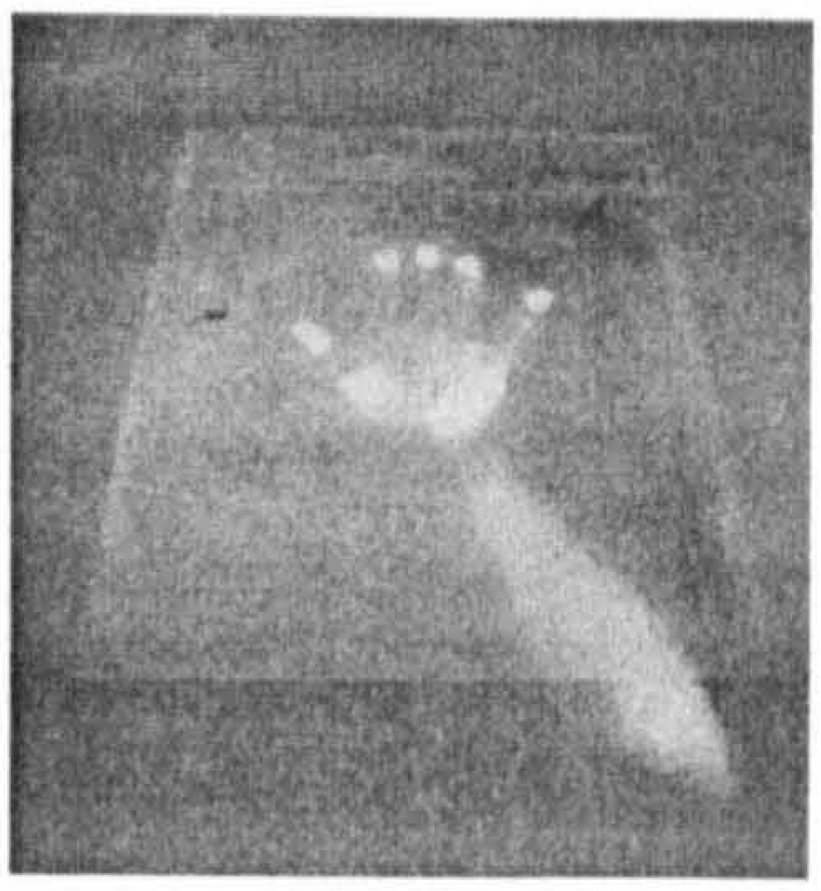
For the production of the work I used a white nonwoven fabric, industrially coated with Phase Change microcapsules by Outlast Technologies, that was painted with thermochromic inks. Two types of inks were chosen with low activation temperatures (at 16°C with a threshold temperature at 26°C and at 22°C with a threshold temperature at 31°C) as the typical coldness of walls influence the final WALLPAPER temperature. This is an important aspect that had to be taken into consideration for the colourchange effect to be able to take place in response to human heat. Additionally, Scratch 'n Sniff aroma technology with encapsulated ambrosia, summer flower and eucalyptus scents was incorporated by applying the slurry type liquid onto the colour coded areas using a brush.

The TOUCH-ME WALLPAPER concept of polysensual textiles carries the idea of skin as a complex sensor and receptor, display and communicator, as well as skin as protection and comfort. In my opinion, which is based on peoples response to my work, 'touch sensitive' walls and other surfaces have a potential for applications in future design that is becoming increasingly senses-orientated. As described earlier, future and research orientated companies including Outlast Technologies are seeing a large market segment for

258 TOUCH-ME WALLPAPER, 2003.

259, 260
Temporary bodily imprints on a 'touch formulated' thermochromic fabric.





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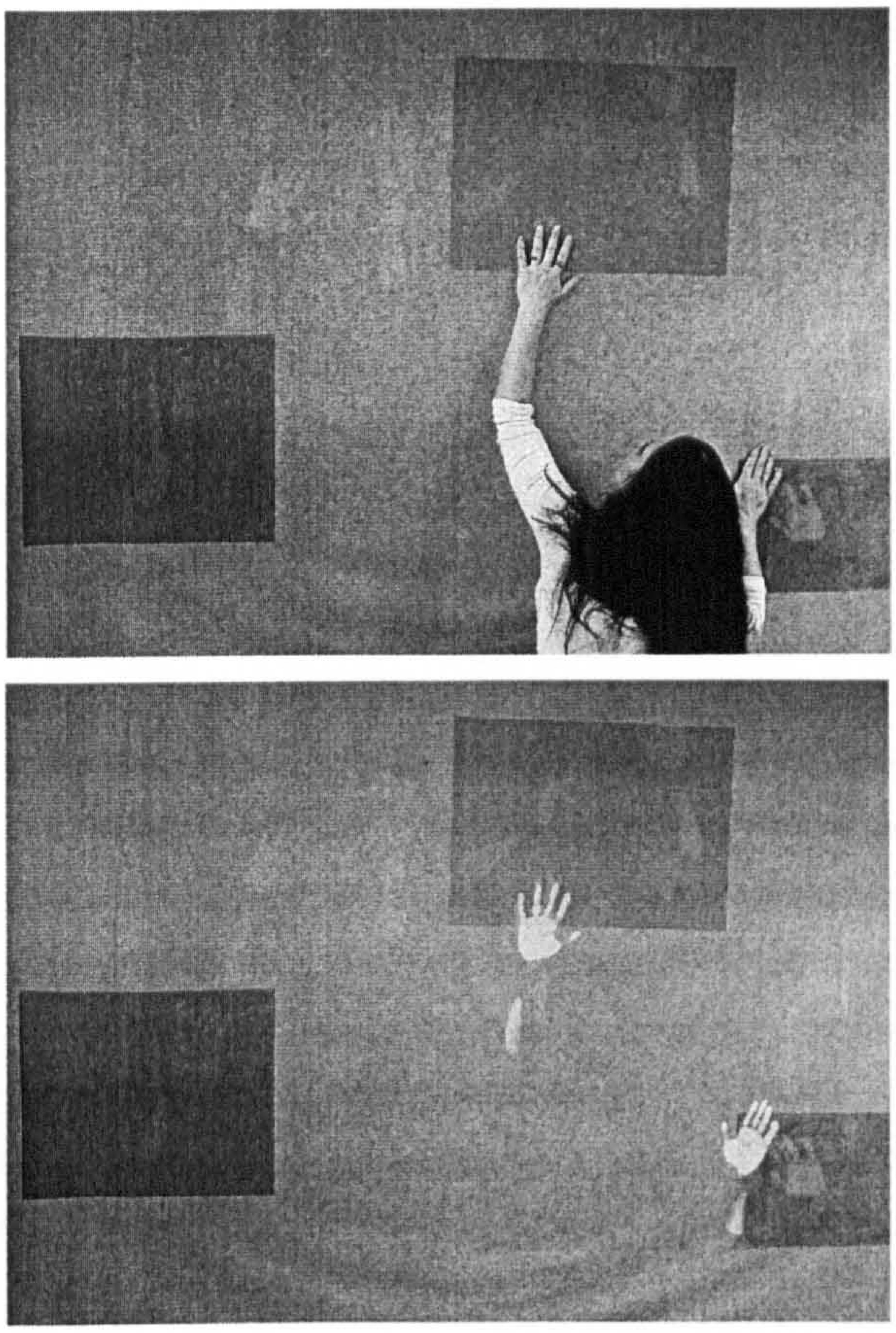


261, 262
'Before' and 'after':
Interaction with the
TOUCH-ME
WALLPAPER.

261, 262

such haptic products. Colourchange environments would be particularly useful for applications in places that are designed for children or, particularly, for the visually impaired. Apart from the purposes of aromatheraphy as also discussed earlier (11.2), the integration of scented messages into environments and objects would be beneficial to blind people, as their olfactory sense is much more developed and they have to rely on it for spatial orientation. The response from the audience to this work was particularly positive. People liked to interact with the textiles wall by sniffing it, leaving their hand prints and observing how they slowly disappear from the surface like shadows. Many people (mostly adults!) appreciated this tactile experience immensely and admitted that they had 'great fun' with it. People found the idea of touching things that we do not usually touch and having unexpected sensory experiences interesting and capable of adding an extra value to our everyday surroundings.

The concept of an interactive sensory-appeal textile membrane could be used for health care applications, in public waiting rooms and as a learning environment for children that supports their sensory worlds. Such environments could also be healing for mentally ill people and help to recall them from their weird worlds. In future the TOUCH-ME WALLPAPER concept could be extended using HEAT 'N SNIFF technology (11.2.2) so that a switch or a remote control can be used to activate the scents for more effective delivery, in addition to a manual method if desired. An opposite concept of smell-absorbing textile technologies for healthy environments could be also used by incorporating products such as Breeze® (11.2.3) that absorb all smells including malodours or BaKaSave® (11.2.4) that absorb certain harmful substances in our environments.

INSTRUCTIONS ON HOW TO INTERACT WITH THE WORK:
Put your hand on the surface of the textile wallpaper to view the colourchange effect and to experience the aromatic oils of the Touch-Me Wallpaper.

- by simply touching the surface of the Touch-Me Wallpaper in any place you will activate the colourchange effect of the work
- please note that depending on your own body temperature and current temperature in the room you might need to hold your hand in the same position for up to 30 sec. to reach the colourchange effect
- by gentle rubbing of the surface activate one of the colour-coded areas and experience it's scent
- all three colour-coded areas have different olfactory experiences to offer:
  pink = Ambrosia, ochre = Summer Flowers, violet = Eucalyptus

12.4 SENSORY SCREEN

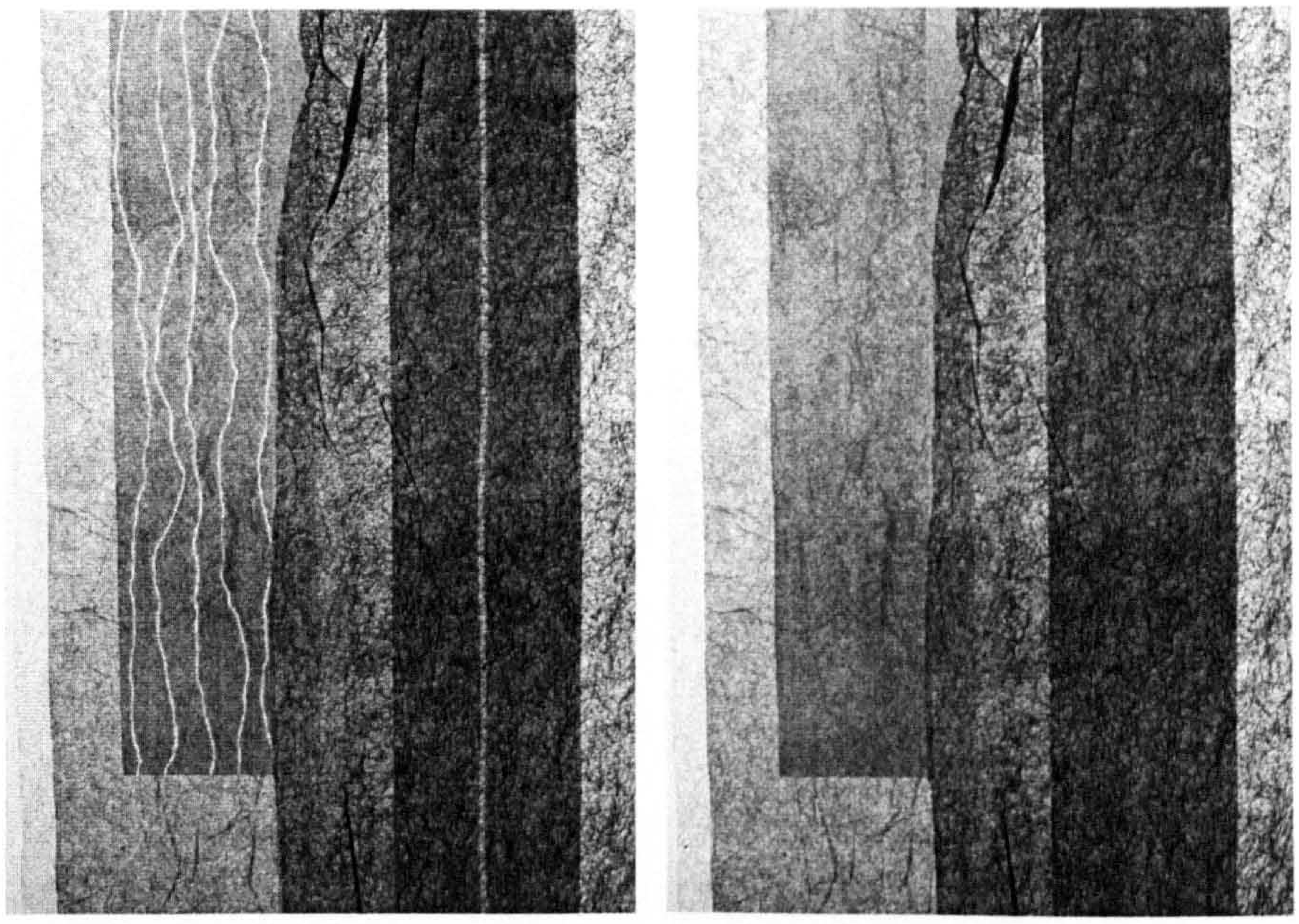
Object dimensions: 5 pieces, 0,6 m x 2,5 m each

Connectivity & Contribution to New Knowledge:
The installation mimics skin properties, which are regulated by our nervous system. It comments on biological and psychological aspects of the skin such as sensory, display, communication and metamorphosis. The operating principle of this space divider is based on the VERSICOLOUR system as described in more detail in Section 11.1. Within this system thermochromic materials react to increasing or decreasing heat initiated by electric stimuli with a colourchange effect. It is possible to control the colourchange process by opening or closing the circuit as and when desired. When the electric circuit is open, the space divider reveals latent patterns associated with the nervous system's network, by reacting to the heat created by the electric current flow through the conductive thread incorporated into the base material.

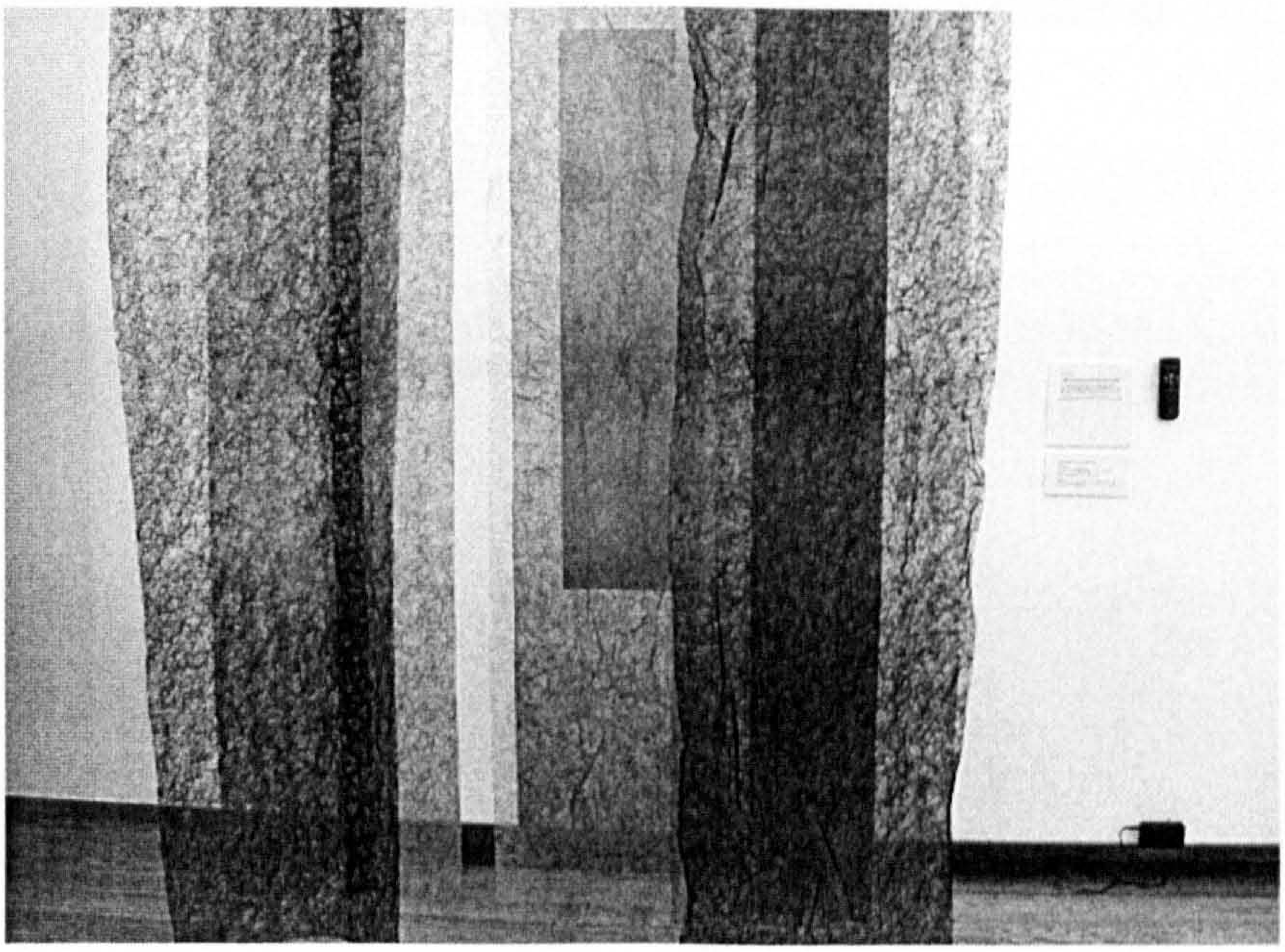
Various industrial textile materials were used for the production of this work: technical Colbond WA 30 and WA 50 nonwovens, flame retardant DROP SCREEN PAPER®, adhesive SPUNFAB webs, electro-conductive stainless steel filament yarn with average linear resistance (R) 14 Ω / m, thermochromic inks and electric current. A power supply with a maximum output of 30 V and 2 A regulated by a remote control was also employed.

Various tests using nonwovens were executed in order to facilitate the analogy of the nervous system at work - neurons sending the information collected from the outside world to the brain by electric impulses. I have chosen electricity as a tool for making drawings that visually and technically reflect this process. Linear graphic patterns of lines occur in places where conductive threads or metal wires are incorporated when a current passes through. Due to the heat created by the resistance of conductive threads the colourchange process of thermochromic inks is activated (Section 11.1 on the VERSICOLOUR system).

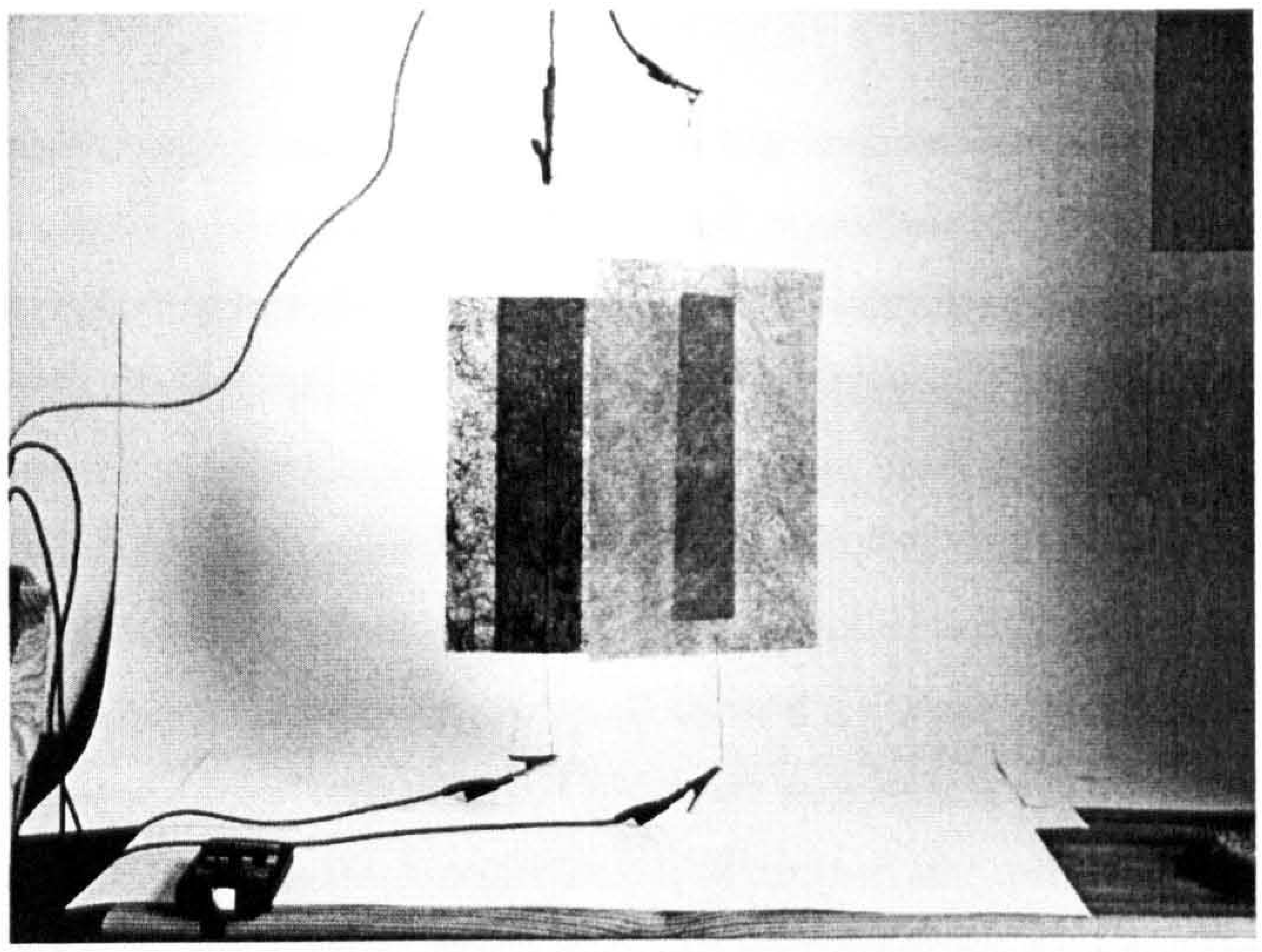
In the A4 size tests I had to be careful not to use too high voltage as this could cause burns in the structure of the fabric. However, making the final SENSORY SCREEN prototype pieces I faced the opposite problem – insufficient production of heat for a successful colourchange effect because of the low resistance of the material due to its length. After doubling the thread this problem was solved. However, I could only use a maximum thread length of 15 m as it would take too long to heat up sufficently (using the power supply available) to initiate the colourchange in the final design. Therefore patterns had to be kept simple. Currently it takes about 5 sec. when the first signs of colourchange occur and about up to 25 sec. when the pattern is seen in full detail.



263, 264 SENSORY SCREEN, 2003.

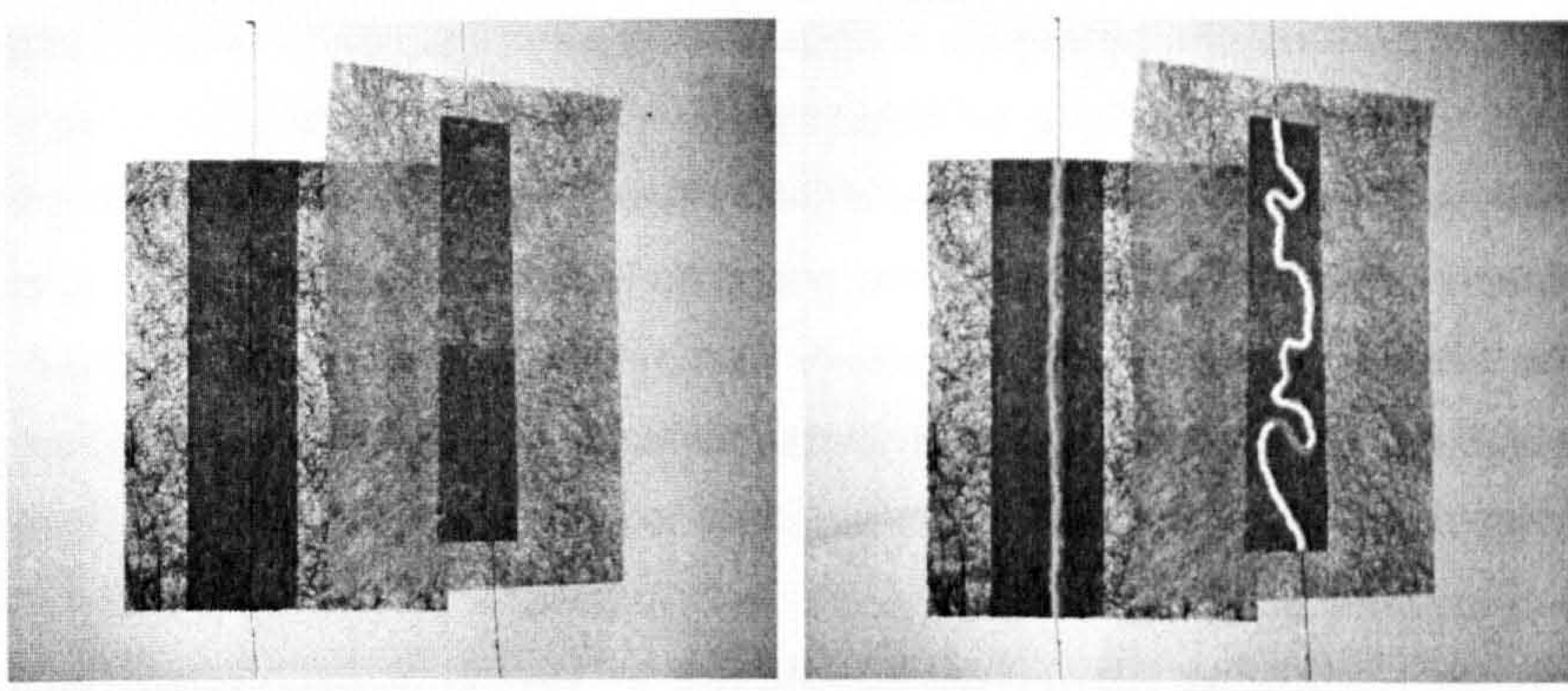


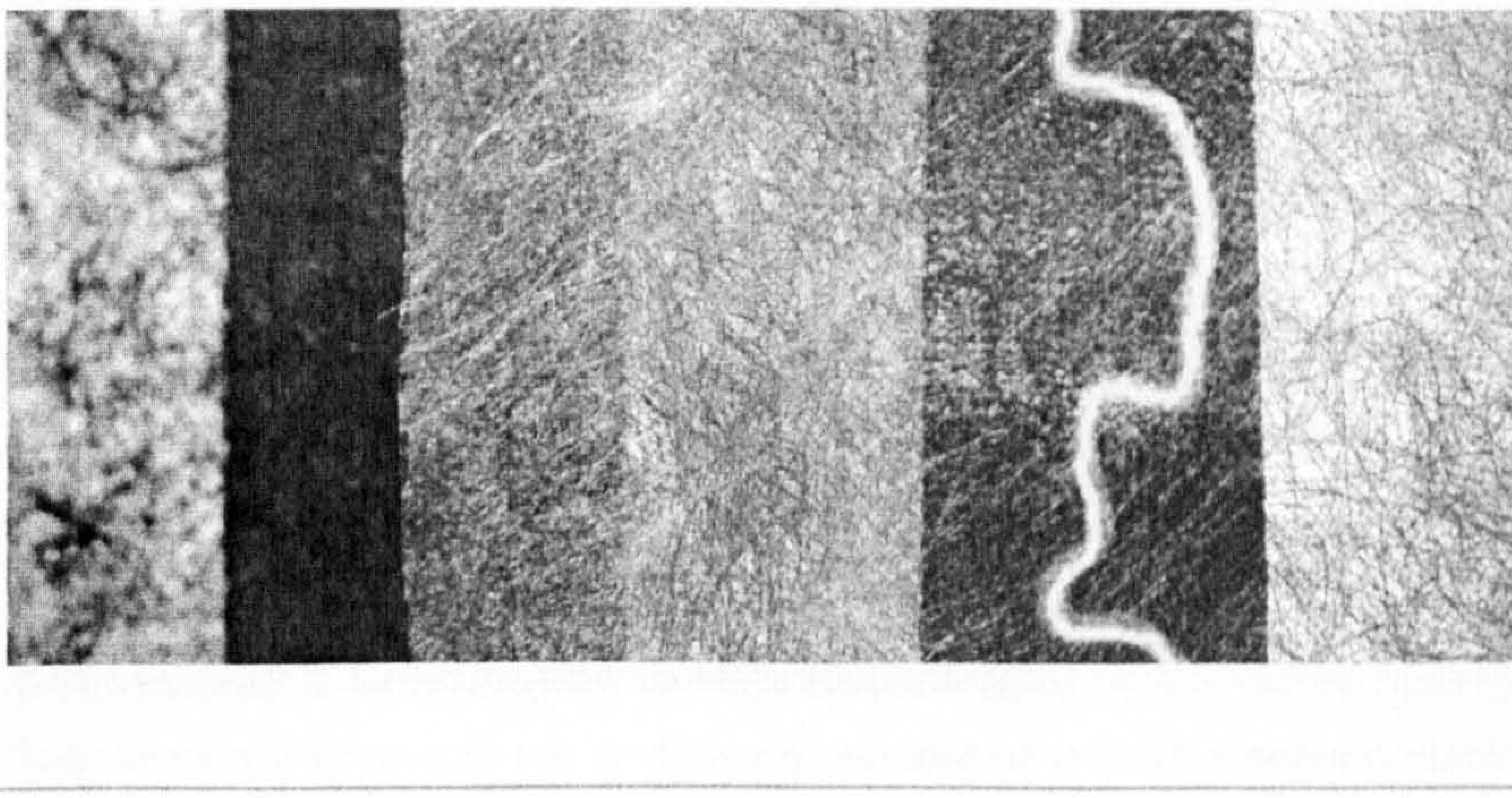
267 Installation
SENSORY SCREEN, 2003.



265 An experiment using electric heat to stimulate colourchange effects in thermochromic textiles.

Nonwovens, stainless steel thread, thermochromic inks, electric current, power supply and electric wires.





266 A, B, C SENSORY SCREEN, prototype

Additionally I was concerned with the layered structure of skin. To address this issue I used varying densities of spunlaid nonwovens with a distinctive fibrous structure by layering and bonding them together with the fine adhesive SPUNFAB® webs that would not destroy the particular translucent quality of the textiles. Prior to this treatment the nonwovens were dyed in beige tone baths to obtain warm skin-like shades. The flame-retardant DROP SCREEN PAPER® that is a nonwoven inheriting both paper- and textile-like qualities was painted with an orange thermochromic ink. Due to its solid surface properties it served as an excellent 'screen' for the physical colour-change plays. Sandwiched between two layers of DROP SCREEN PAPER® the network of fragile electronics was well hidden and protected. When activated by passing through the current, the magnified and rationalised nervous system patterns became visible, as if they were inscribed on the textile skins - analogous with tattoo patterns. This work evoked particular interest from a group of architects, probably because it was the most technically accomplished and had clearly communicated its utilisation possibilities. They could directly envisage it integrated into an environment. The principle of a SENSORY SCREEN design could be applied in psychiatry, for public waiting rooms, dentist ceilings, health resorts or in places like restaurants, clubs and boutiques where the possibility of changing ambience would bring economical benefits. There is potential for this technology to advanced by progressing from an analogue system to a digital for more refined displays (see Section 11.1.2). This could also be used for displaying electronic or digital maps and other information.

INSTRUCTIONS ON HOW TO INTERACT WITH THE WORK:
To view the latent pattern of the Sensory Screen

- press the 'on/off' button on the remote control once pointing it towards the infra-red box
- allow around half a minute for the pattern to show up
- the pattern will disappear after you press the 'on/off' button once again
- after doing so, allow approx. 3 minutes for the pattern to disappear

12.5 SENSE WALL PANEL

Object dimensions: 2 pieces, 0,3 m x 0,25 m each

Connectivity & Contribution to New Knowledge:
This work contributes to the underlying concept of skin as a sensor, display and communicator - a medium that is capable of reflecting our reactions to various psychological or physical stimuli coming from the outer world. In order to establish this analogy Thermochromic Liquid Crystal materials were employed. These are highly sensitive to the slightest changes in temperature within the pre-formulated temperature response

range (see 10.4.2.1). Coupled with electronics that produce heat, Thermochromic Liquid Crystal (TLC) materials perform transient colourchange plays in response to fluctuating heat conditions.

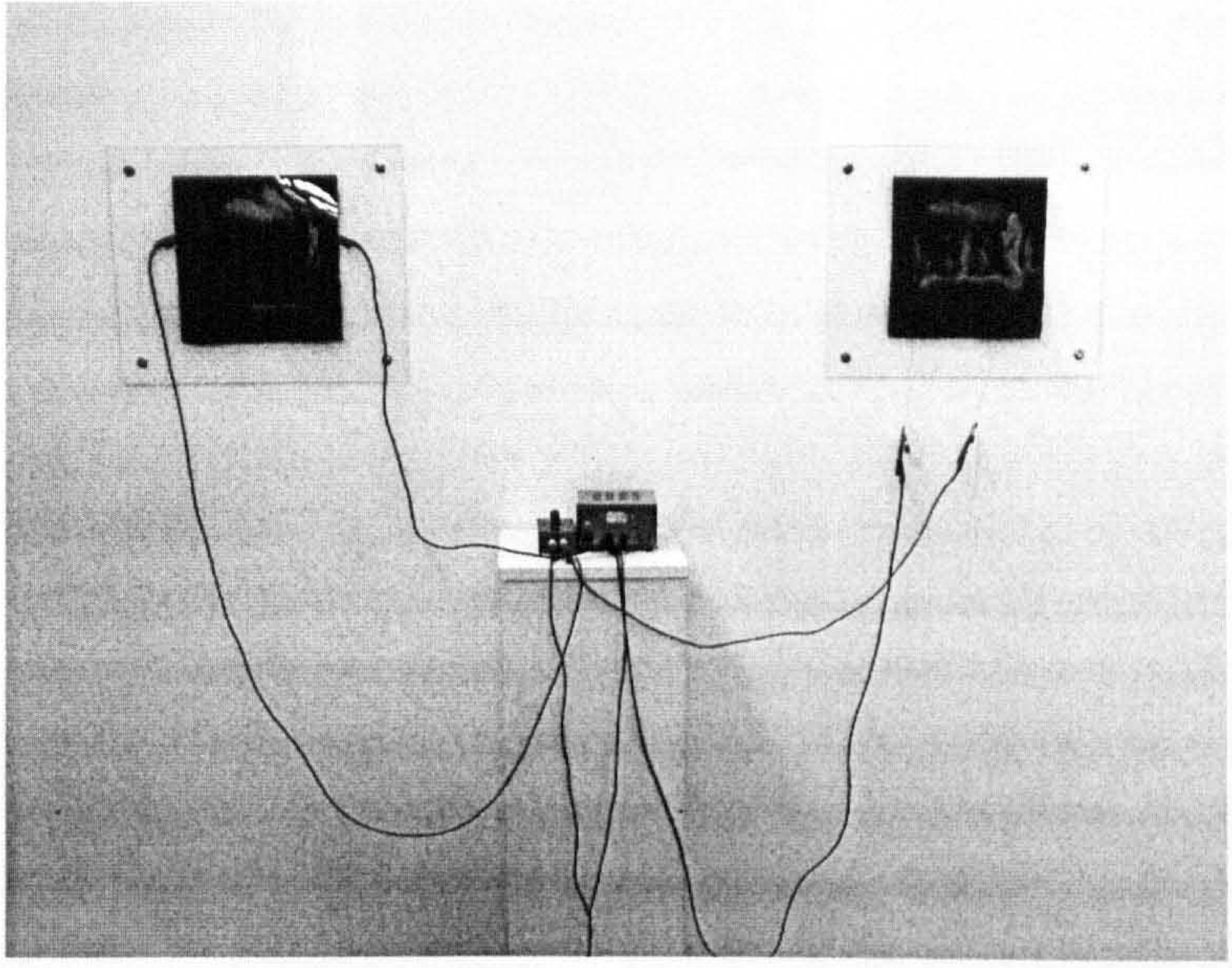
SENSE WALL PANEL is a working prototype for intelligent signage that could be incorporated directly into the surface of a wall or attached to it as a removable panel. This might be used for public venues such as bars, clubs, conference rooms, etc. enabling the display of information at times when appropriate. Such panels could also be used to change the colour of an entire room or isolated sections of the wall. Furthermore creation of various decorative patterns is possible.

The operating principle of the VERSICOLOUR system that is incorporated in this work is based on the colourchange properties of thermochromic materials reacting to increasing or decreasing heat initiated by electric stimuli from a power supply, as described in Section 11.1.3. The latent letters that form the word 'sense,' as well as the square-shaped pattern, frequently change colour in sequence from black to tan, to green then blue, as the temperature increases and back to black again as the temperature falls below the activation point of the TLC.

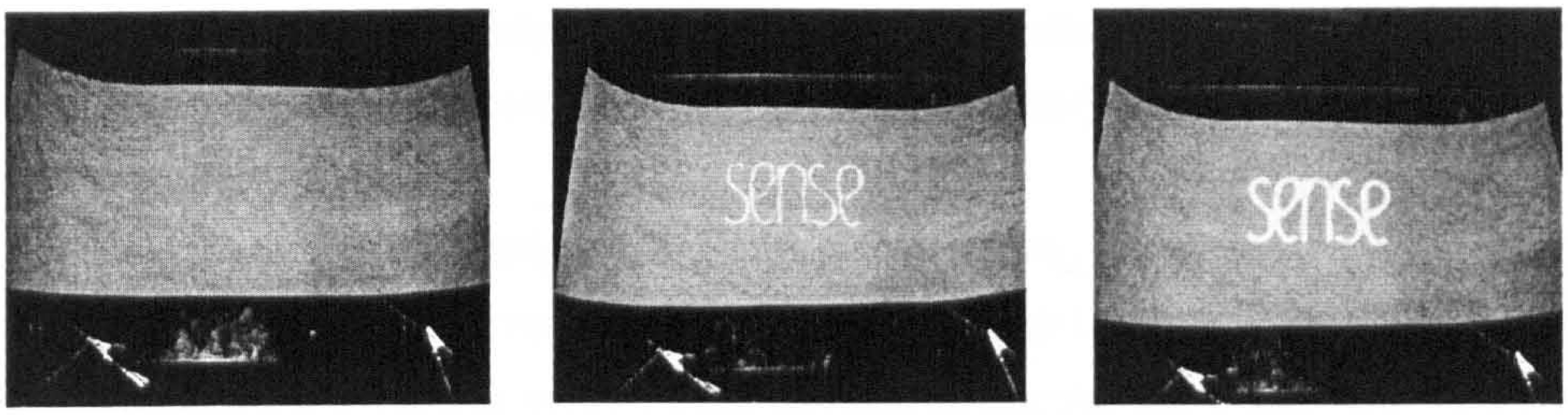
The SENSE WALL PANEL prototype uses analogue techniques and a timer. The materials used for the production of this work are two black R29C4W (29°C - 33°C) Thermochromic Liquid Crystal polyester sheets, normally used in aeroplane testing to thermally map small temperature changes, a conductive stainless steel filament yarn with an average linear resistance (R) 14 Ω / m for the word 'sense', cardboard coated with conductive carbon ink for the square-shaped pattern and an electric current. The power supply (maximal output of 15 V, 1,5 A) is regulated by a timer set at a 1 minute on/5 minutes off rhythm.

The history of the work involves an experimental stage during which I tested TLC inks for printing applications and their reaction to UV light. Due to the specifics of liquid crystals the iridescent colour effect is best visible when ink is printed on a black background. Therefore, only black and very dark colour backgrounds were used for my printing tests.

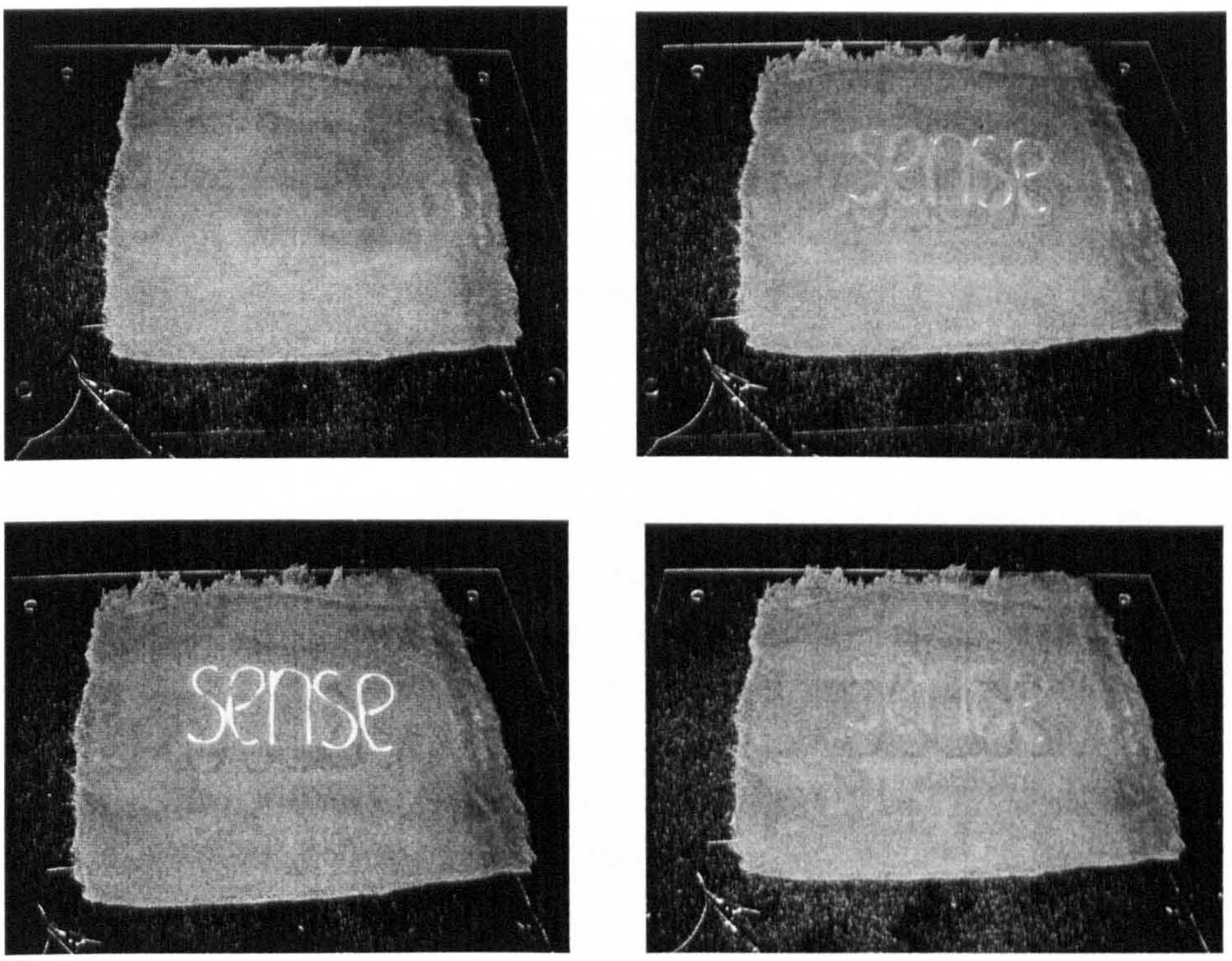
It is known that TLCs are UV unstable but I wanted to find out when exactly the irreversible changes in their molecular structure start to happen and to what degree. After exposing small printed samples to sunlight behind a glass window for 1, 3, 6, 12 and 24 h respectively, it was found that the first visible changes, mainly represented by a weaker colourchange effect upon heating, appeared after 3h. After 24h of exposing the sample under UV light, no signs of colourchange phenomena were found. It has to be concluded that, despite their aesthetic appeal, there would be serious practical



268 'SENSE' WALL PANEL, 2003.



269 A, B, C Experiments.



270 A, B, C, D Experiments.

disadvantages for using TLC printing inks because the designs would always have to be kept out of UV light, unless UV light protective windows are installed. Additionally, these inks are extremely expensive (approx. £1000/liter).

Next I looked into possibilities for UV protective coating and arranged with the company Sericol for some samples to be treated with their UV light protective varnishes. Unfortunately, the coating modified the specific colourchange qualities of TLC (changing from black to dark blue only) as the molecular structure had obviously been affected. A similar thing happens if the printed surface is over-exposed to touch and hence body sweat. After these experiments I decided to concentrate mostly on the more robust Thermochromic Molecular Rearrangement Technology (10.4.2.2). Technical problems occurring, including the design constrain of having to use a black background and also the high cost of TLC seemed too prohibitive to consider further tests.

However, the SENSE WALL PANEL has been made exclusively using Thermochromic Liquid Crystal polyester sheets that are industrially coated and therefore not that sensitive. Kept out of UV light, the object treated with the Liquid Crystals functions as a reversible indicator of changing temperatures applied using electric heat. Having considered the negative aspects of the product, as a designer I think that in some cases the unique colourplay, atmospheric aesthetics and the outstanding quality to 'sense' changes in temperature as small as 0,5 °C might outweigh the disadvantages.

As with my other work the SENSE WALL PANEL DRAWS reference from the biological mechanisms of a sensory skin. The word 'sense' embroidered using conductive threads below one of the TLC screens stand for the nerve receptors that carry impulses collected from the outer world to the brain. The latent text becomes visible only when an electric stimulus is passed through the thread causing resistance heat that disappears again if there is no further electric input provided. The supply of current is controlled by a timer that rhythmically opens and closes the electric circuit resembling a slow breathing pattern.

The work suggests a potential for applications ranging from an informative screen to a decorative wall panel, from graphical images to overall colourchange effects. The surfaces can be programmed to perform controllable colourchange patterns in a 'pulsating' wave-like motion, in sections or overall, resembling the process of blushing of living skin. This principle could contribute to signage design by allowing specific information to be displayed, incorporated into walls, ceilings, floors and carpets, only when there is a demand or need for it. It would also enhance public and private spaces by offering fluid colourchange environments that could be controlled manually or pre-programmed. In the future these environments might be capable of intelligently 'sensing' and adapting to a person's mood.

Technically, it is possible to have several 'layers' of texts, patterns and/or designs, which can be activated when needed, allowing the changing of informative or visual input as required. For more sophisticated displays, it is possible to use digital control systems directed by a computer program (for example, software LABVIEW made by National Instruments) that can send signals to electro-conductive patches located on a X-Y matrix in order to switch each patch independently on or off. Depending on the size, shape and density of the distribution of patches/pixels, simple to highly complex images could be rendered on almost any surfaces treated with thermochromic inks (Liquid Crystals or Molecular Rearrangement Technology) as described in Section 11.1.2.

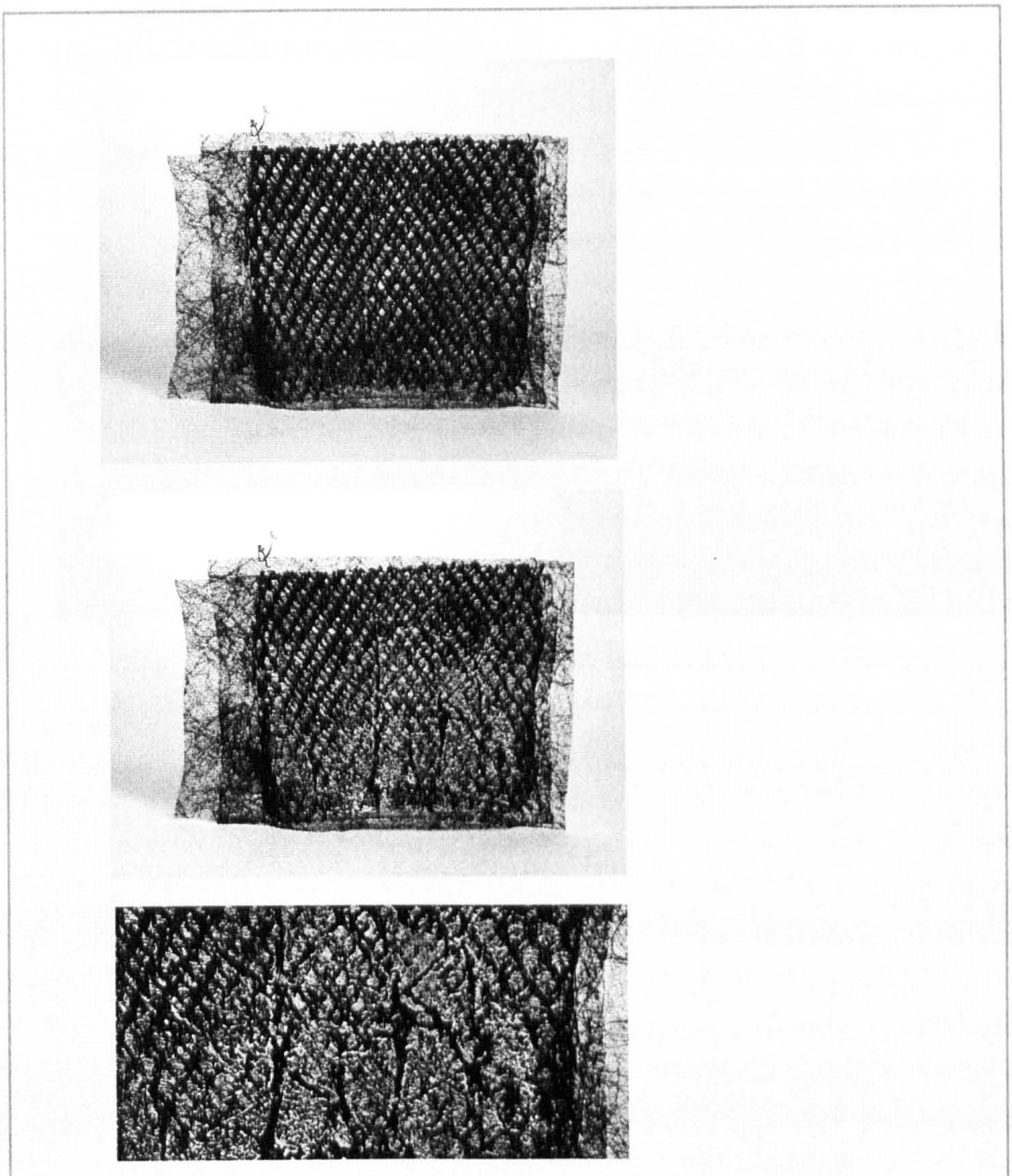
More advanced digital systems could possibly be developed on the basis of this work. It would be challenging to integrate a software system that enables people to interact with textiles by drawing a pattern, or a sign on a computer screen, that would be then directly translated onto the thermochromic fabric surface. Pressure could also be translated, for instance, into abstract colourchange patterns reflecting the place and intensity of the touch applied on a specially designed 'sensing' device that sends stimuli to the electronic textile membrane through the 'brain' of a computer. In fact, the fabric would become a soft screen that responds to the movements of a human hand thus embodying the analogy of intimate contact between two people.

12.6 INTERACTIVE SKIN ARCHITECTURE PIECES

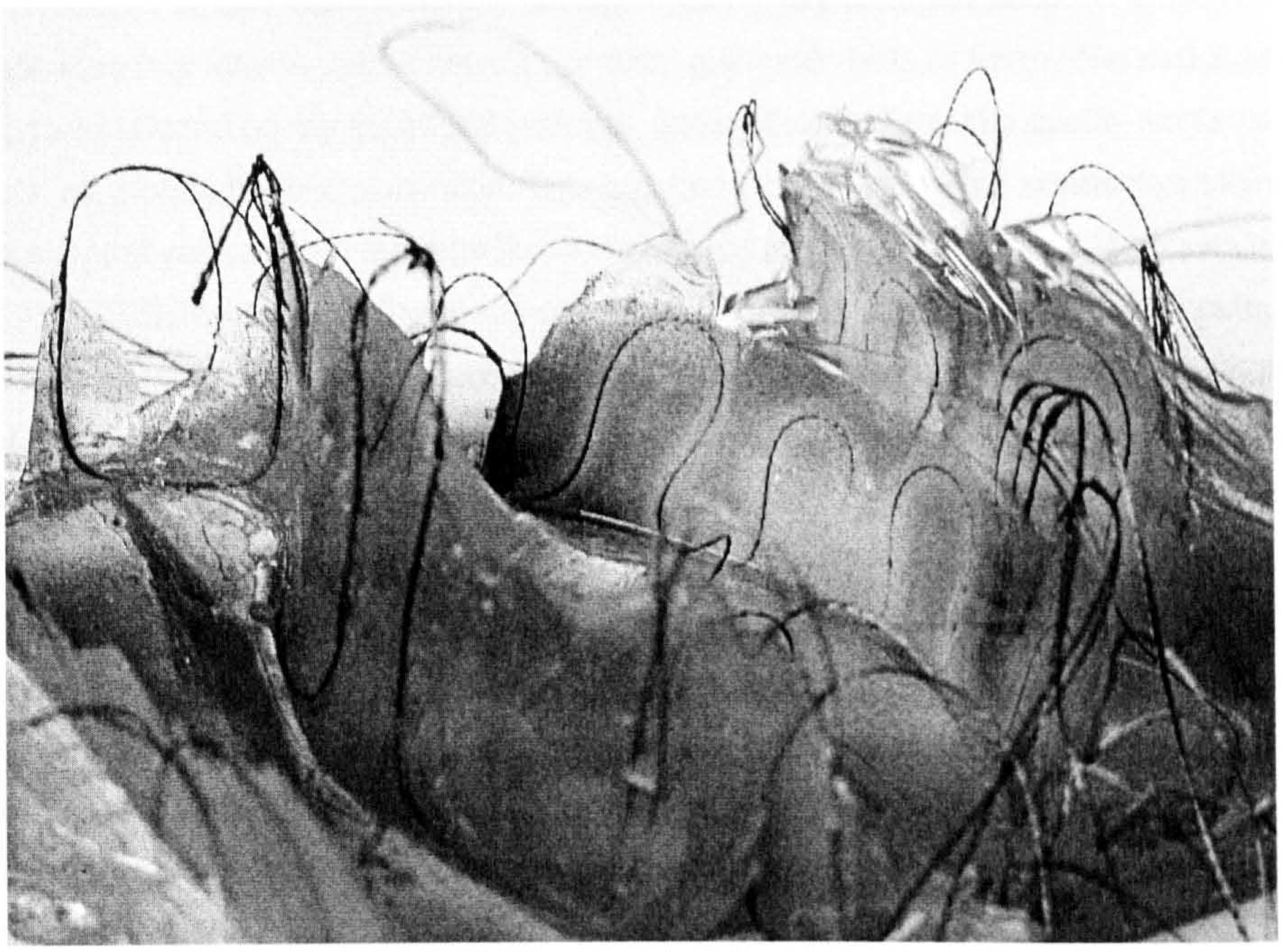
Object dimensions: 4 pieces, 0,25 m x 0,15 m x 0,10 m each

Connectivity & Contribution to New Knowledge:
INTERACTIVE SKIN ARCHITECTURE PIECES are based around inspiration derived from the living skin network systems - magnified skin structures, its construction and technology. The work series makes reference to the interactive mechanisms of our body including our sensory and vascular systems, sweat glands, hair and skin cells, which all work together in harmony to form or support the functions, processes and the physicality of our skin tissue.

The work consists of three magnified 'skin' pieces, which perform different interactive functions and are concerned with the three-dimensional qualities of skin. The technologies incorporated include the VERSICOLOUR system (11.1.2), the MULTICOLOUR CHROMIC DESIGN system (11.1.4) and the HEAT 'N SNIFF technology (11.2.2), all stimulated by electric heat and developed during my practice led research. All three pieces are three-dimensional representations of different skin constructions. They make reference to its various functions, which are sustained by the sensory system of living skin.



271 A, B, C Experiments using Liquid Crystal inks.



272 INTERACTIVE SKIN ARCHITECTURE PIECES, 2004

INTERACTIVE SKIN ARCHITECTURE PIECES are looking at what we are but in a way that makes us seem overwhelmingly strange – extremely enlarged sections of skin surface feature hair inserts, nerve network circuits, giant skin cells or furrow-like structures. I have used silicone as my sculptural material, finding that its flesh-like quality works as a natural allusion to the body and skin. This has been combined with a conductive stainless steel filament yarn with an average linear resistance (R) 14 Ω / m, technical nonwovens, DROP SCREEN PAPER®, thermochromic inks (Molecular Rearrangement Technology), microencapsulated aromas and an electric current. The power supply (maximum output of 30 V, 3 A) can be optionally co-ordinated by a switch, a timer or a remote control to regulate the colourchange and/or smell release processes.

One of the pieces (example No 1) is a study of an enlarged epidermal structure, based on the semi-random patterns of a network of furrows. DROP SCREEN PAPER® was covered with thermochromic inks and with microencapsulated aroma 'Ambrosia' ink. It was then doubled and folded in order to achieve organically arranged pleats, which created the three-dimensional structure of skin surface, and which would later be imbedded in transparent silicone. Prior to that a fine conductive thread was incorporated between the two layers thus creating a simple circuit network and making reference to our nervous system.

The three-dimensionally shaped DROP SCREEN PAPER® with the incorporated conductive thread network was inserted in a mould that was covered with a thin plastic foil. Liquid silicone was then applied so that after hardening in some places only very thin layers of silicone were created in contrast to other areas that were completely filled with the silicone mass. Due to the natural creation of irregular folds in the foil, an organic surface pattern was embossed in the thickening silicone membrane, resembling the development of wrinkles. When low voltage is passed through the conductive thread initially, delicate colourchange patterns appear on the DROP SCREEN PAPER® drawing fine light beige linear patterns onto the dark violet membrane. As the resistance heat radiates, the colourchange patterns increase until the entire piece becomes pastel beige. As the heat increases, the object simultaneously releases the light aroma of Ambrosia fragrance.

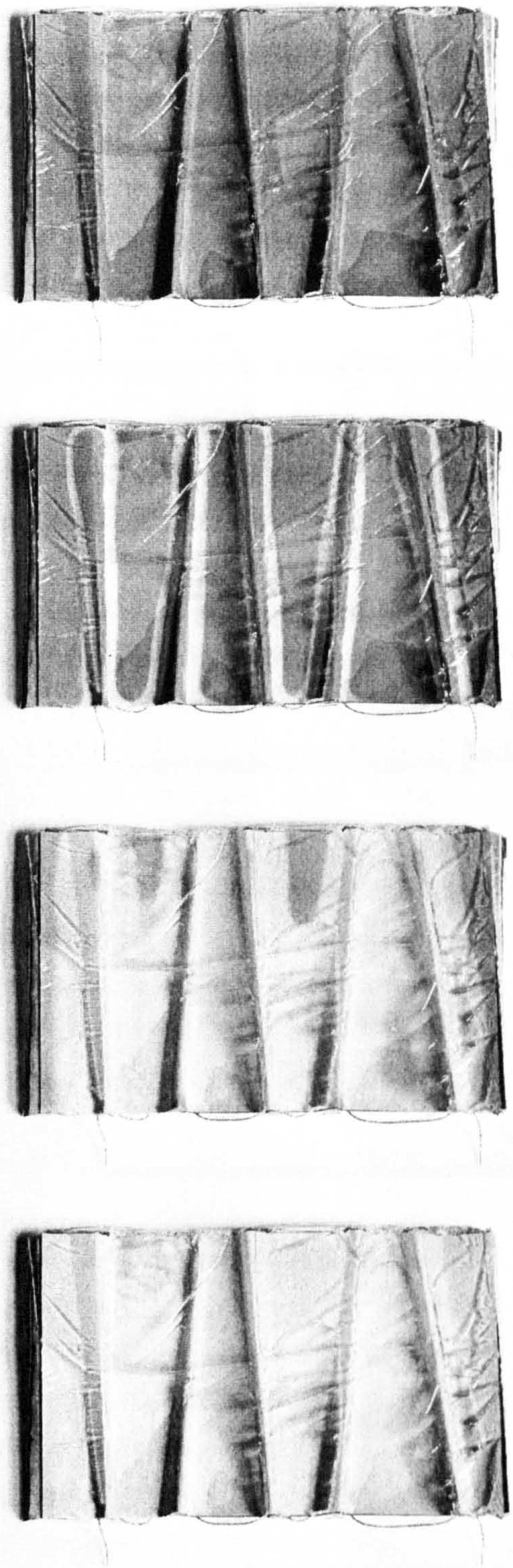
Another piece (example No 2) is concerned with the three-dimensional patterns of dead skin cells. Using the same shibori-like thermo-moulding technique already described (Section 12.1 - MEMBRANES example No 5) I created sculptural representations of the skin surface. Prior to this treatment a pink spunlaid nonwoven was painted with two different colours of thermochromic ink (dark-red with a threshold temperature set at 33°C + black with a threshold temperature set at 25°C on a pink base material) following the principles of the MULTICOLOUR CHROMIC DESIGN system as described in 11.1.4. Additionally some conductive threads were incorporated into the fabric and finally the entire construction was partly embedded in silicone so that only the 'dead cells' would stand out of the solid silicone mass.

When this dark coloured work is touched the round 'cells' perform colourchange by becoming reddish in response to bodily heat. Additionally, when stimulated by an electric current the silicone embedded base material also changes by turning light pink. As a result, by applying different intensities of electric stimuli, it is possible to activate different layers within the same piece of work by achieving fluctuating colourchange effects.

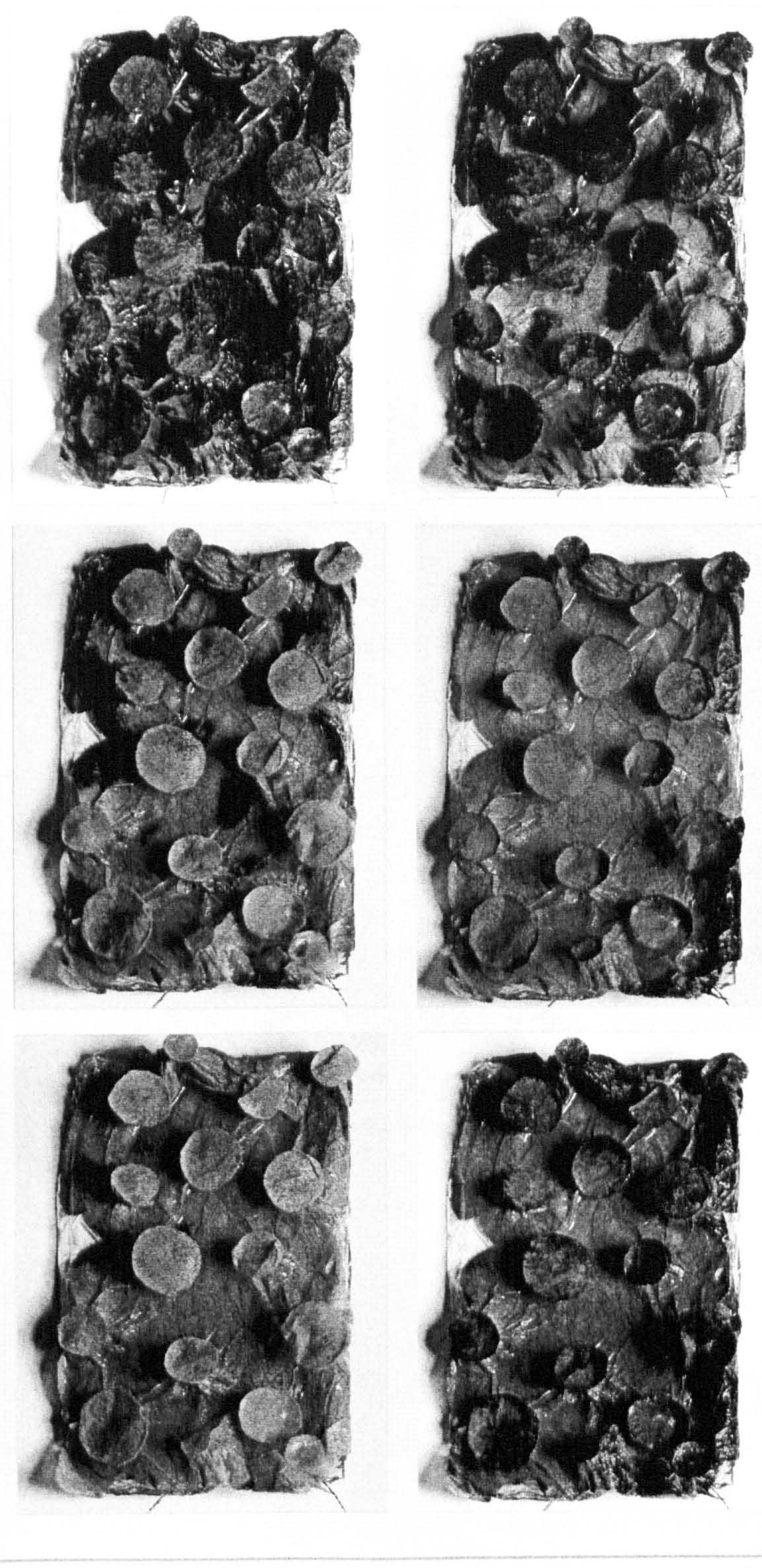
The third piece (example No 3) is based on the analogy of a vertical section of skin tissue, making reference to structures such as hair, nerve circuits and the multiple layers of skin. For the production of this work I prepared several thin layers of flesh-coloured silicone, using thermochromic inks with randomly incorporated electro-conductive threads. After thickening these layers were embedded in transparent silicone, as if they were 'growing' out of it. The 'trembling' quality of the thin silicone sections has its counterpart in the living skin including its sensuous aspects. These seductive qualities are highlighted when current is passed through the entire networked structure creating electric heat. Due to the incorporated VERSICOLOUR technology, sophisticated patterns in white become visible on the fleshy three-dimensional structures. These linear patterns slowly expand covering the entire area that previously was violet-red. The slow radiant colourchange plays offer a calming experience that is almost a meditative one when the viewer takes time to engage in the process.

These sculpturally elaborate models of INTERACTIVE SKIN ARCHITECTURE aim to offer unusual sensory experiences that simultaneously involve sight, smell and touch. They can be used as precious objects or decorative tiles applied in a series or as one-off pieces. Furthermore, their integration in interactive interiors would enhance people's senses and their wellbeing by releasing aromatherapeutic fragrances, performing soothing colourplays and intimately responding to touch. Such a multi-sensorial concept would be particularly useful for private environments – at home or in the office. It could offer a unique sensory experience which could enhance people's emotional and physical wellbeing in calming and therapeutic ways, and also provide a unique personalised environment.

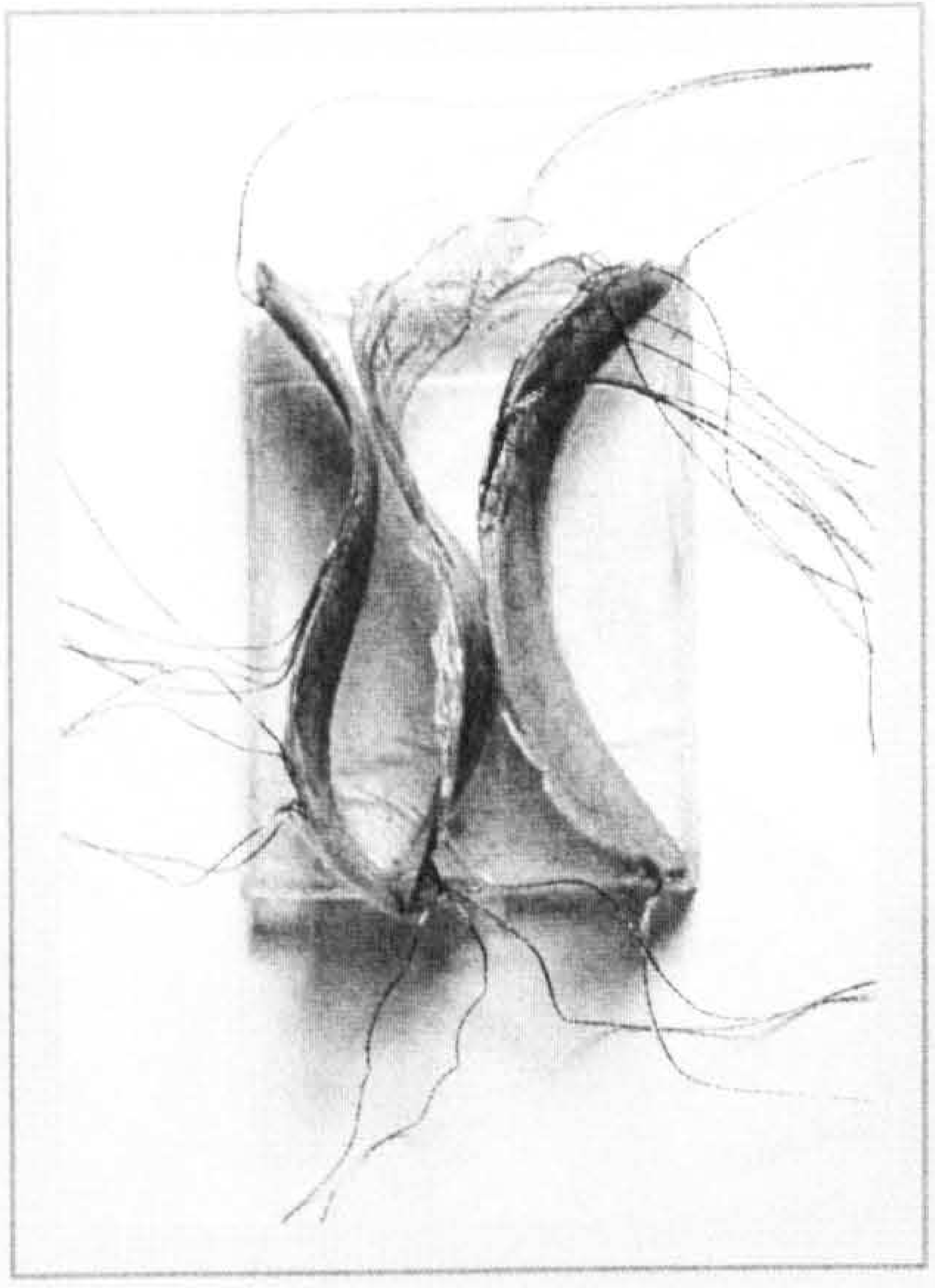
INTERACTIVE SKIN ARCHITECTURE PIECES could be installed almost anywhere that has easy access to a source of electricity and everyone would be able to afford it. The design would introduce flexibility, colour and movement into fixed environments that are typically restricted in these terms and cannot be easily redecorated. Other applications might include places like hospitals, health resorts, cosmetic salons and doctors' waiting rooms where harmonised colour plays alongside tactile, olfactory and audio experiences might help to reduce stress.

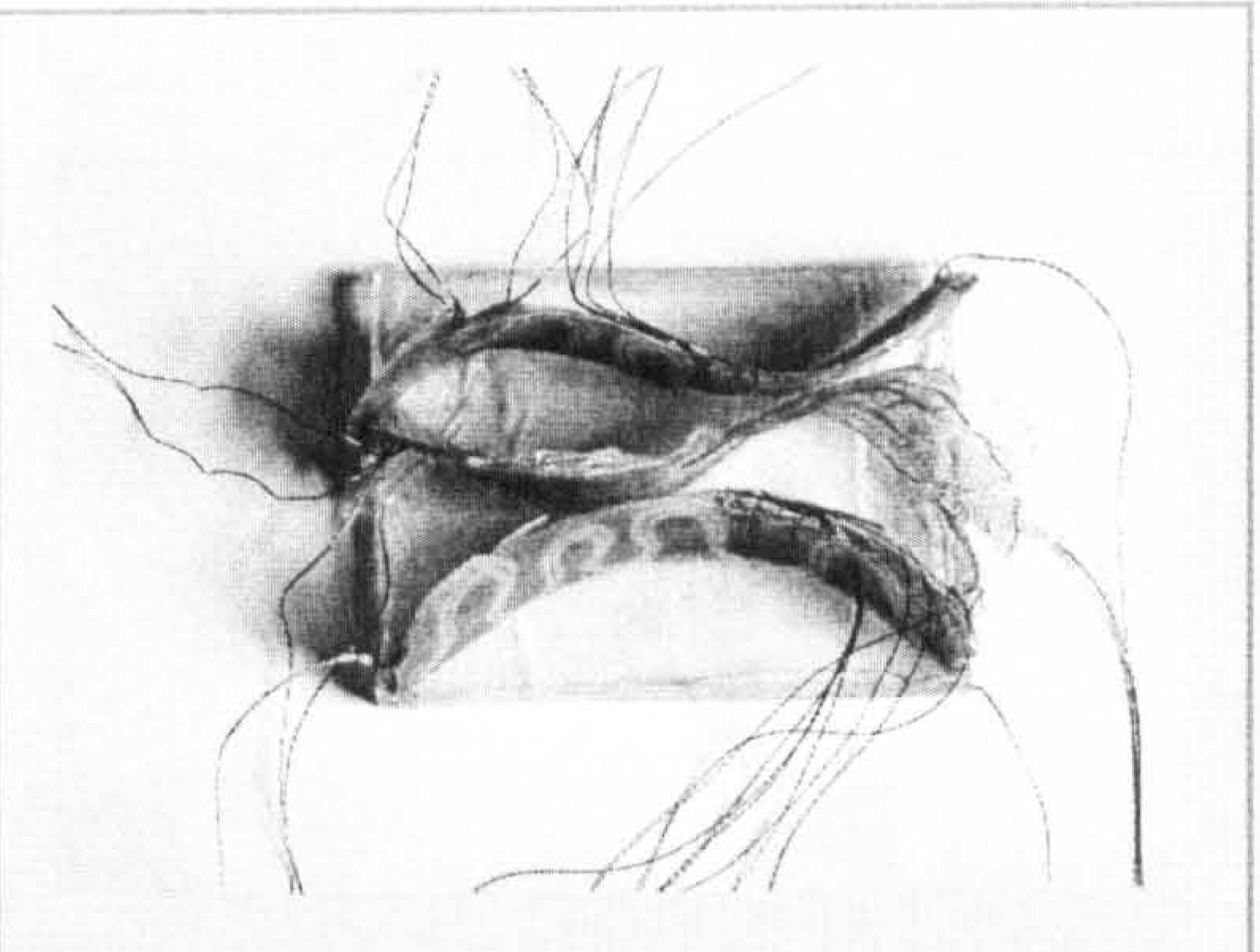


273 A, B, C, D Example No 1.

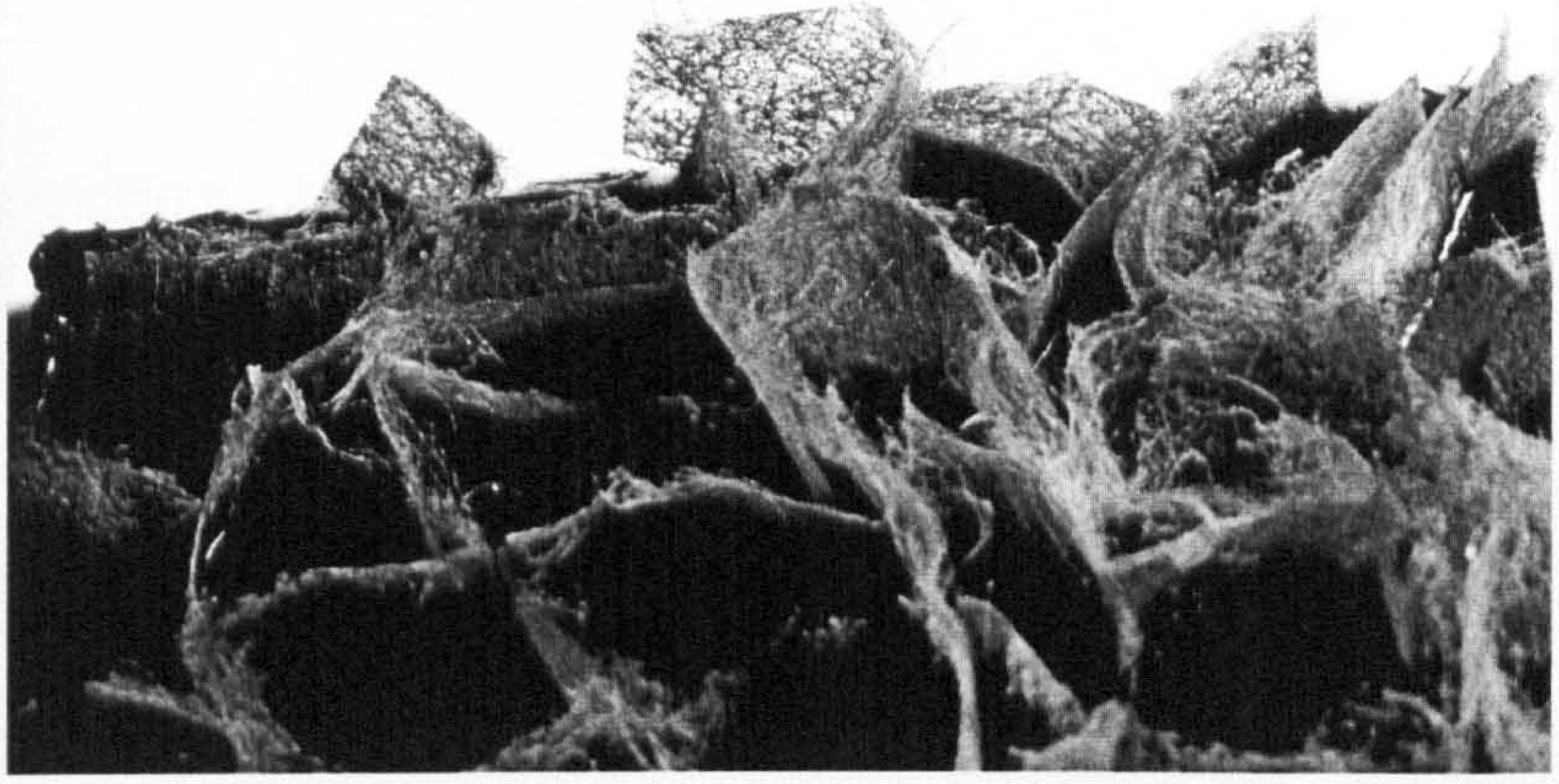


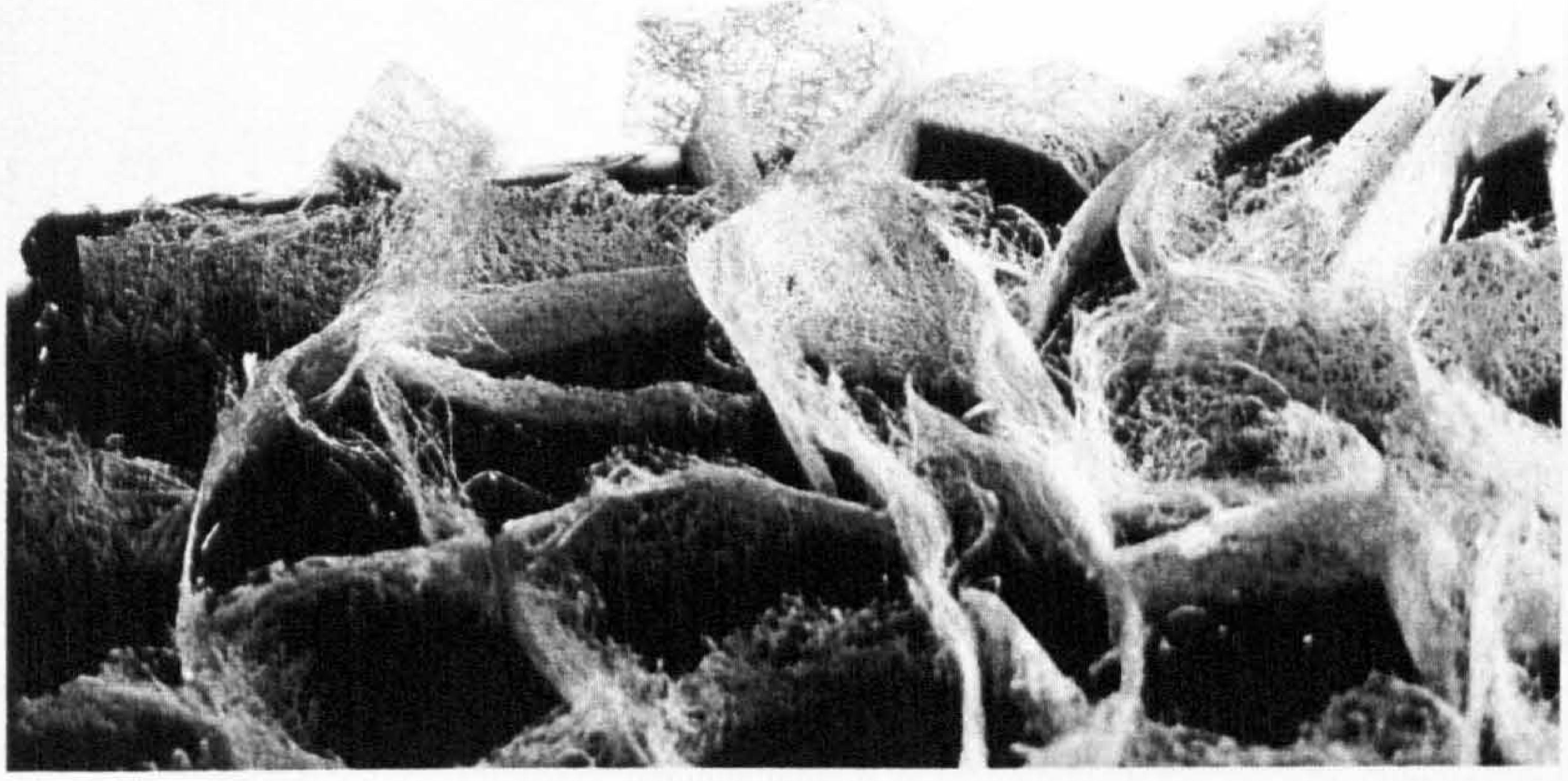
274 A, B, C, D, E, F Example No 2.





275 A, B, C Example No 3.





276 A, B. An experiment using heat sensitive thermochromic inks, coloured silicone and hot air.
SKIN ARCHITECTURE PIECE (A) reversibly changes colour in response to hot air (B).

CHAPTER 13 ::

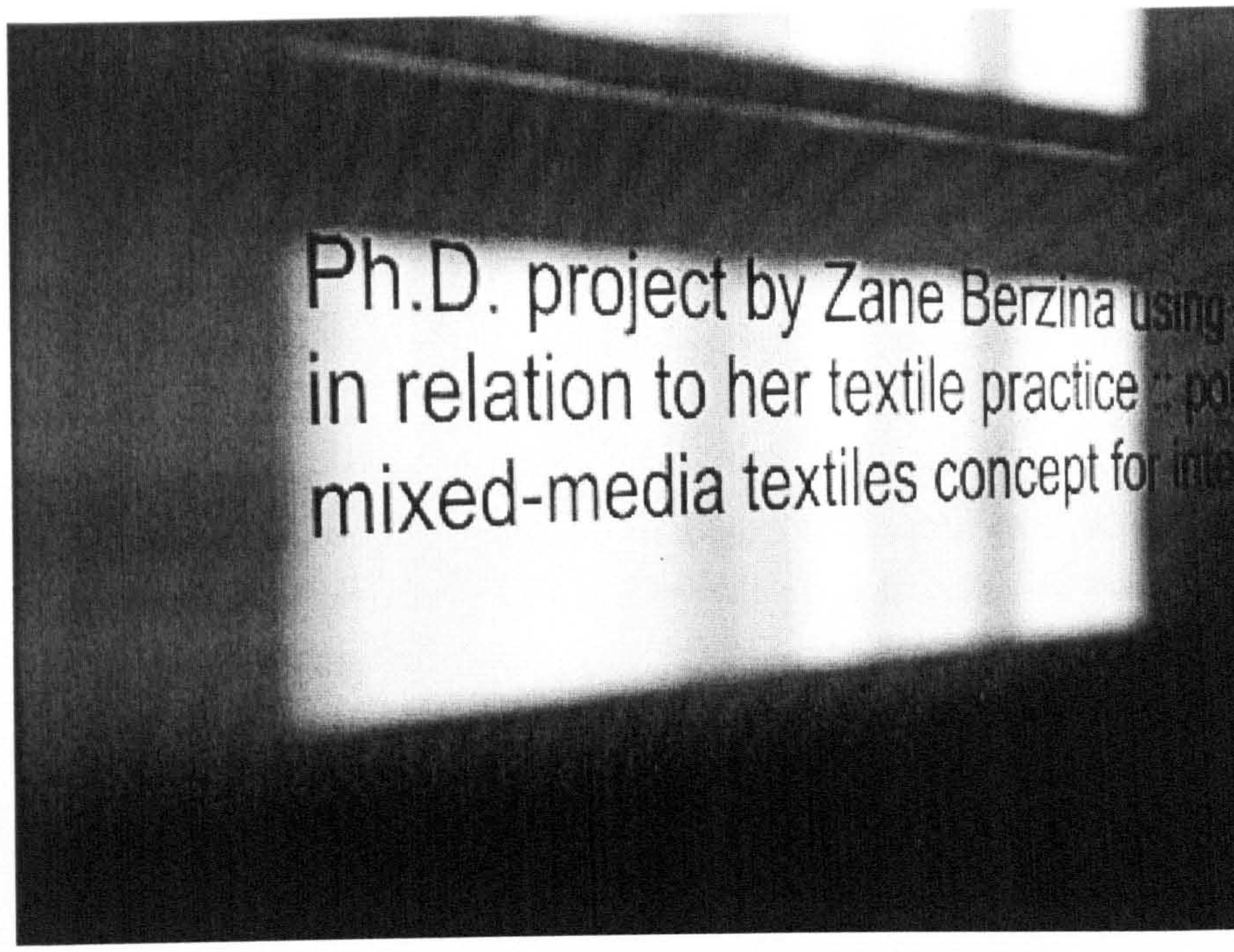
FINAL EXHIBITION AND EVALUATION OF OUTCOME

13 FINAL EXHIBITION AND EVALUATION OF OUTCOME

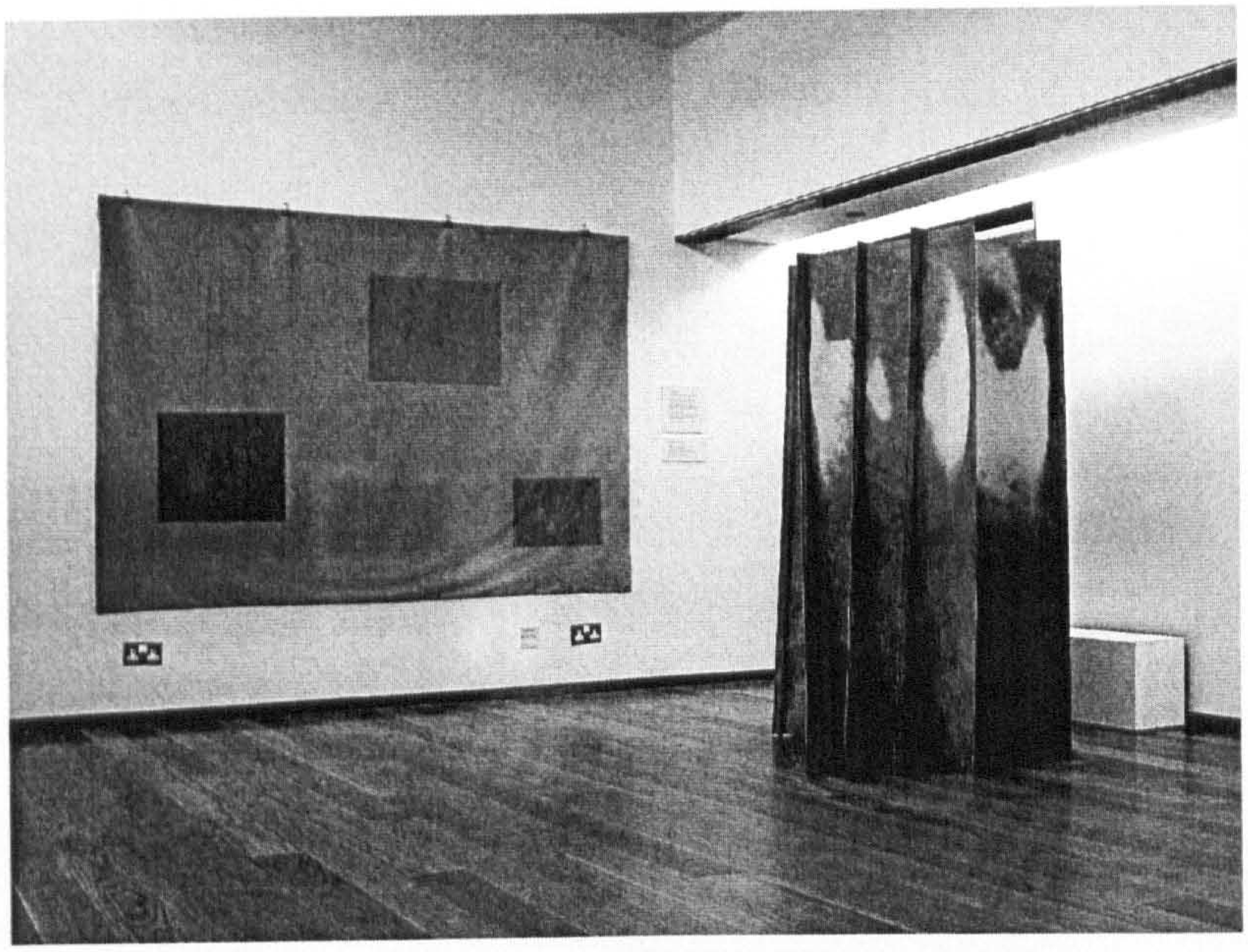
In order to evaluate the outcome of my research experiments an exhibition SKIN STORIES :: CHARTING AND MAPPING THE SKIN was set up at the Fashion Space Gallery, London College of Fashion, LINST from October 27th until November 8th 2003. The aim of this exhibition was not only to reflect on the investigation and the results of the practical tests but also to illustrate the journey I made along the way.

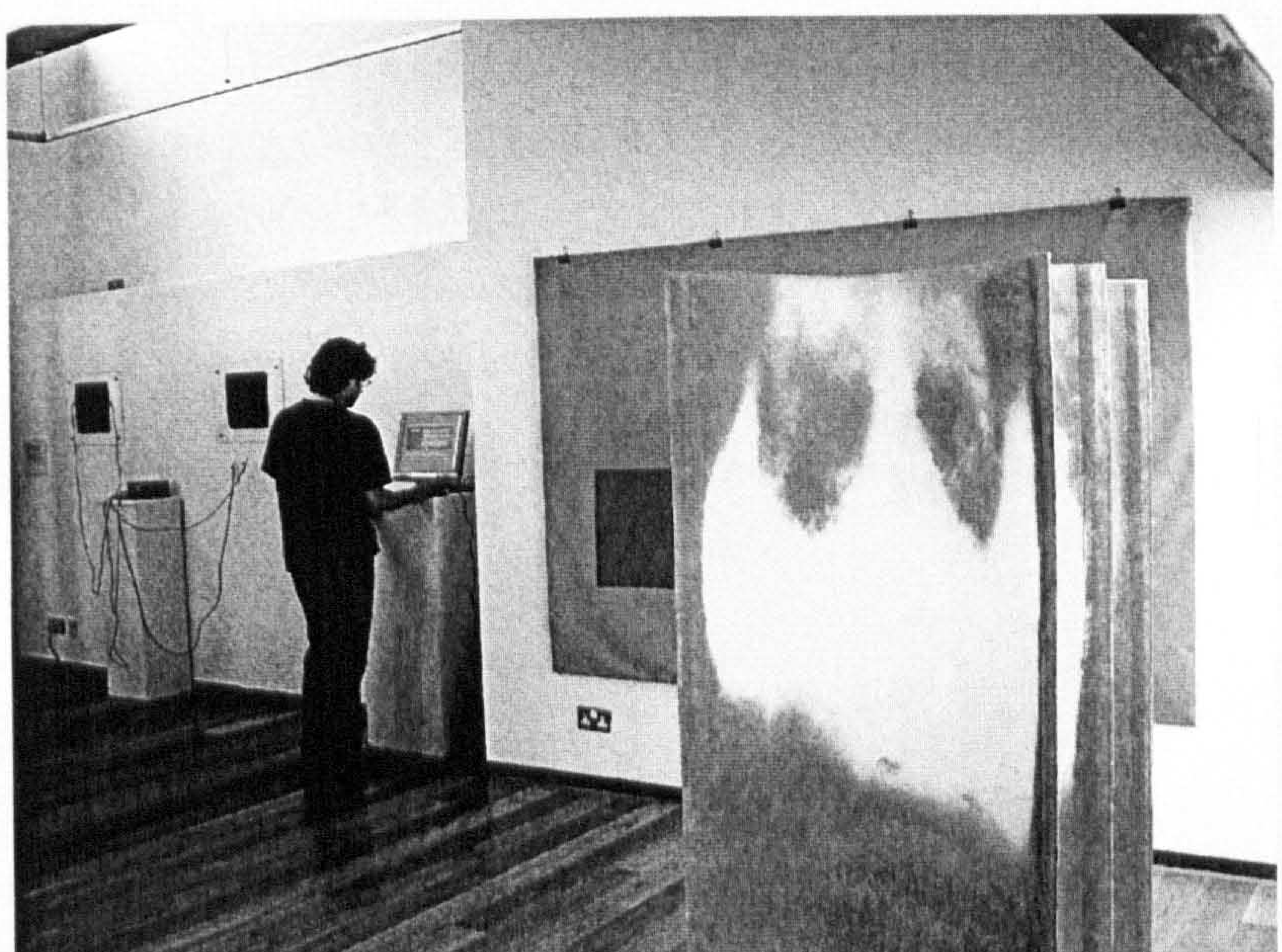
For this reason my textile design prototypes were exhibited, along with selected items used during my research process, to demonstrate the interdisciplinary approach adopted in this project, dealing with various fields of design, technology and science. Items included were biological skin slides prepared for microscopic investigations, micrographs of these skin structures (Zoom-in Gallery, see also Appendix A), skin surface colour photographs (Skin Charts, see also Appendix C), samples of biomedically engineered artificial skin tissues and a range of material samples featuring and summarising the high-tech technologies employed in my work (Material's Corner).

Project log books and textile sample files were also on display as perhaps the best way to demonstrate my design approach to the biological and technological issues discussed. The display was accompanied with an interactive CD-ROM SKIN STORIES, designed by graphic designer Carl Murphy. This was created as a digital representation of my research map, which allows visitors to associate the exhibits with my research themes, introducing the process of following a 'red thread'. The CD has been updated since the exhibition and is now an integral part of this thesis.

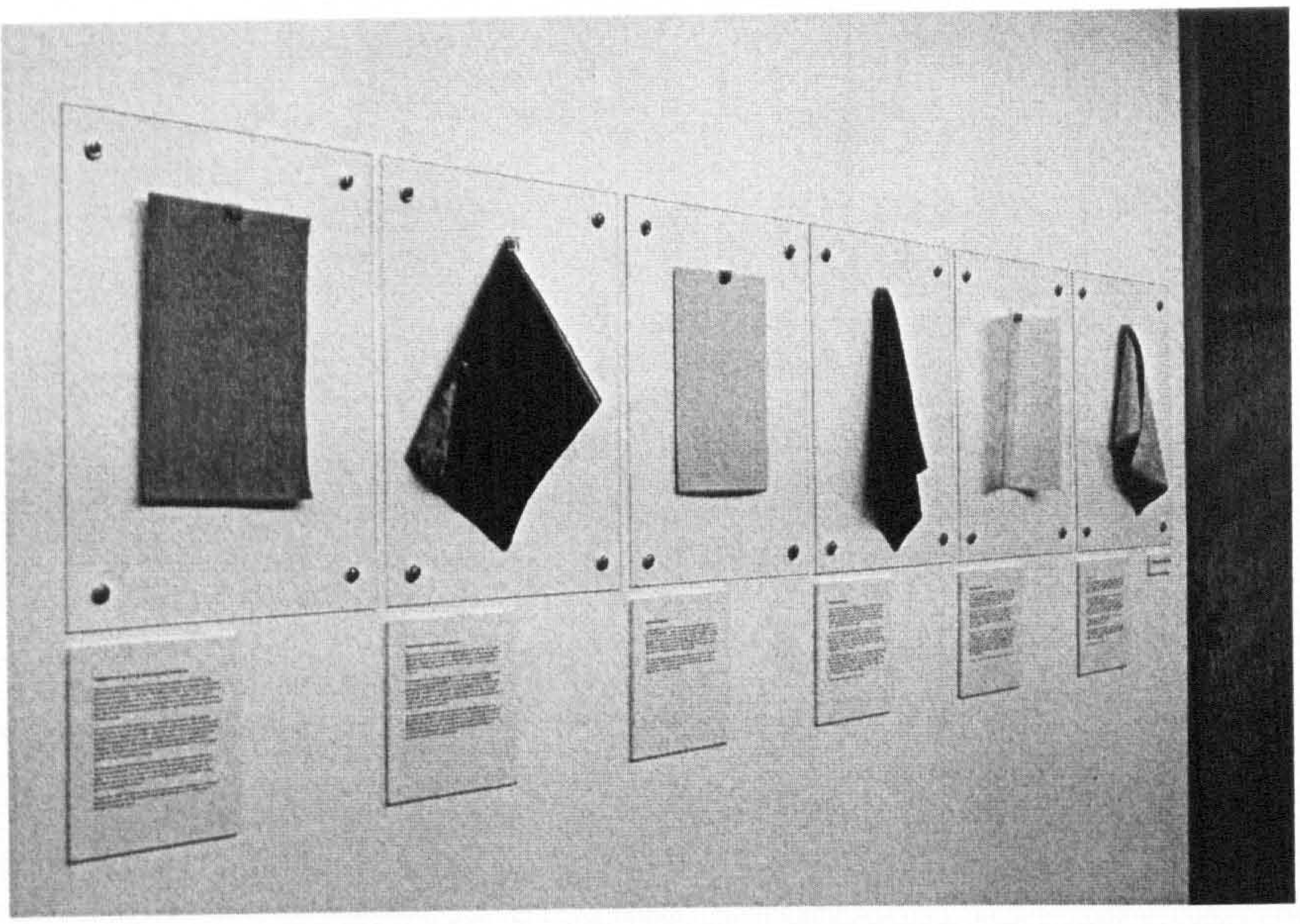


277 A view from the PhD exhibition SKIN STORIES :: CHARTING AND MAPPING THE SKIN, 2003, LCF

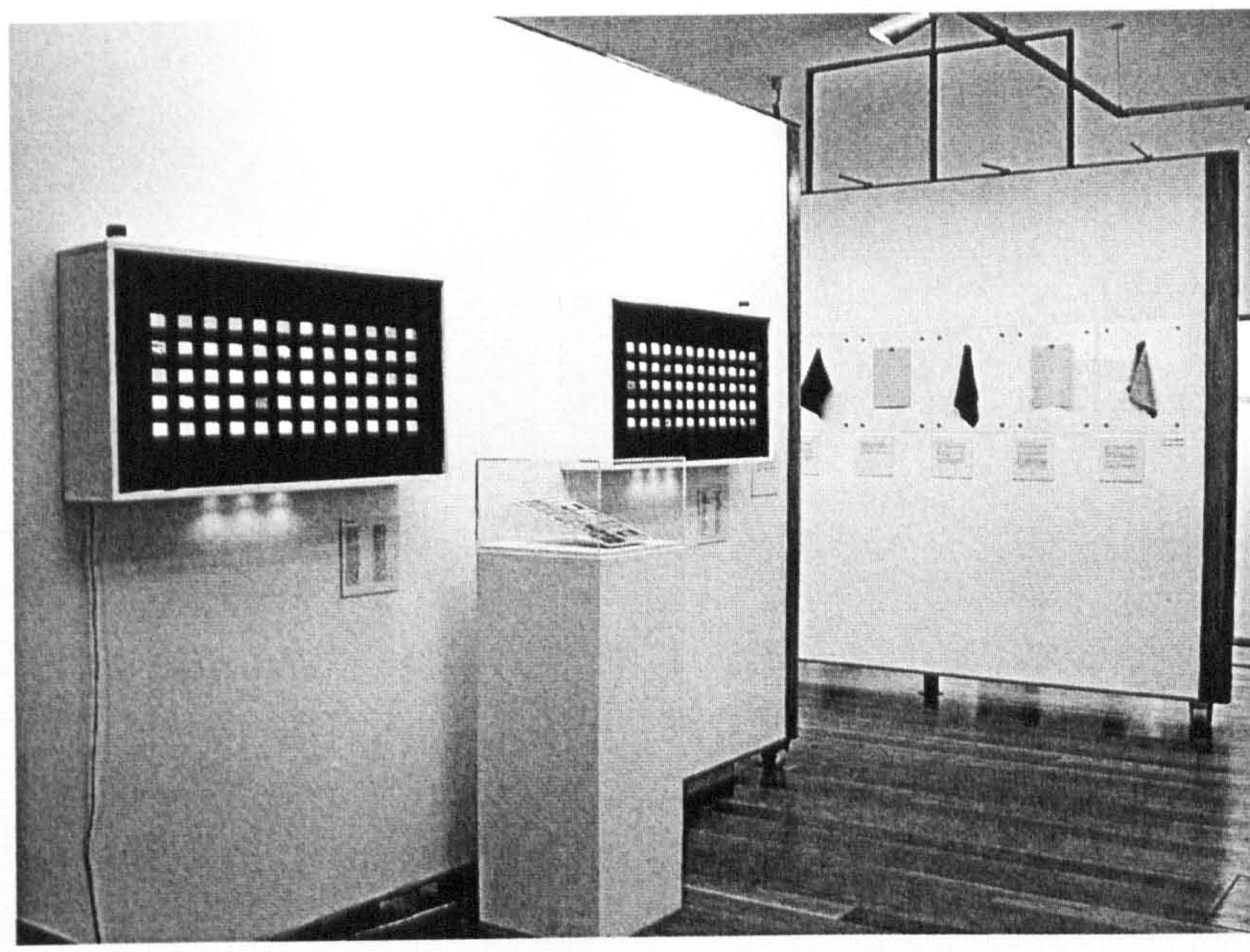


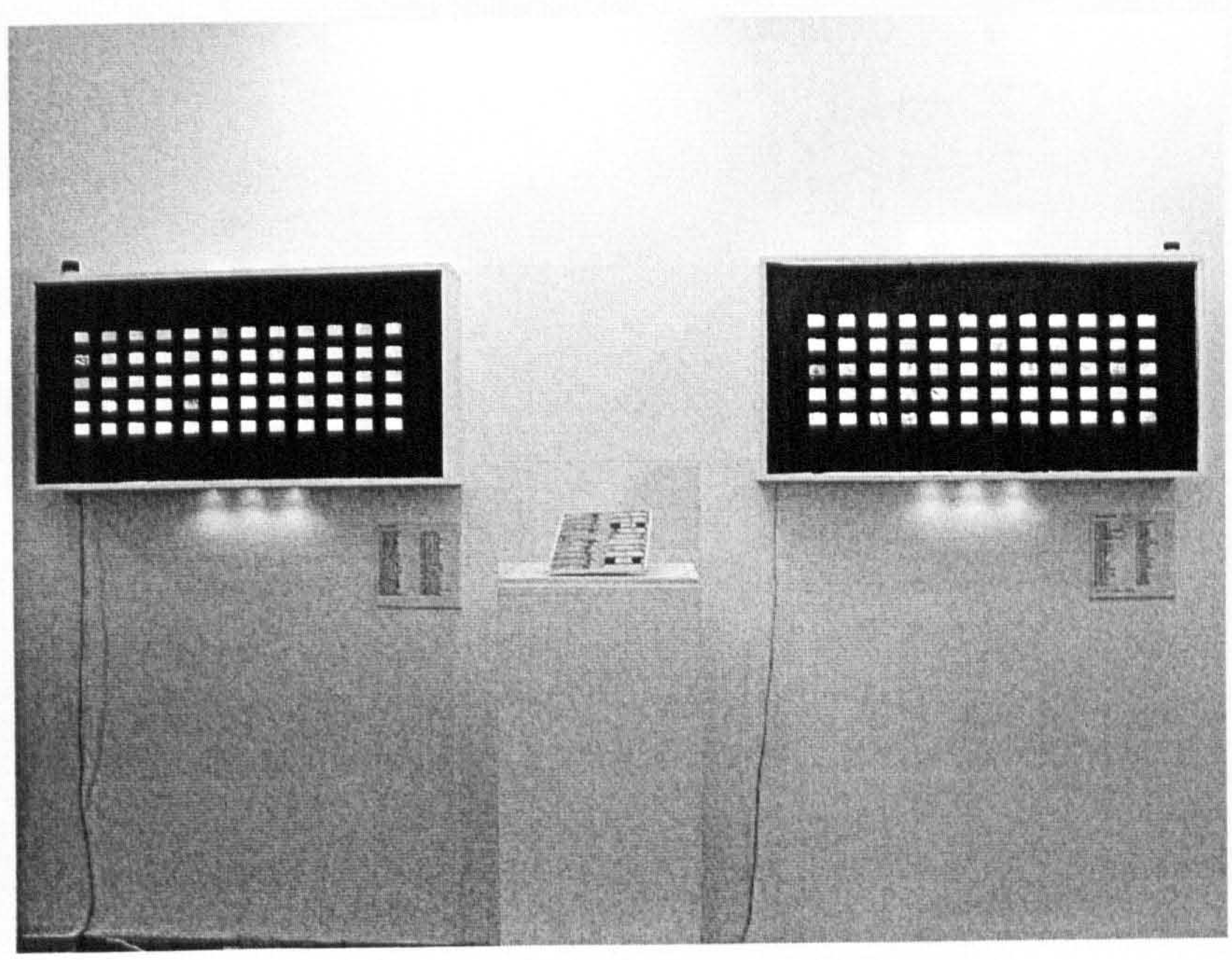


278, 279: A view from the PhD exhibition SKIN STORIES : CHARTING AND MAPPING THE SKIN, 2003, LCF

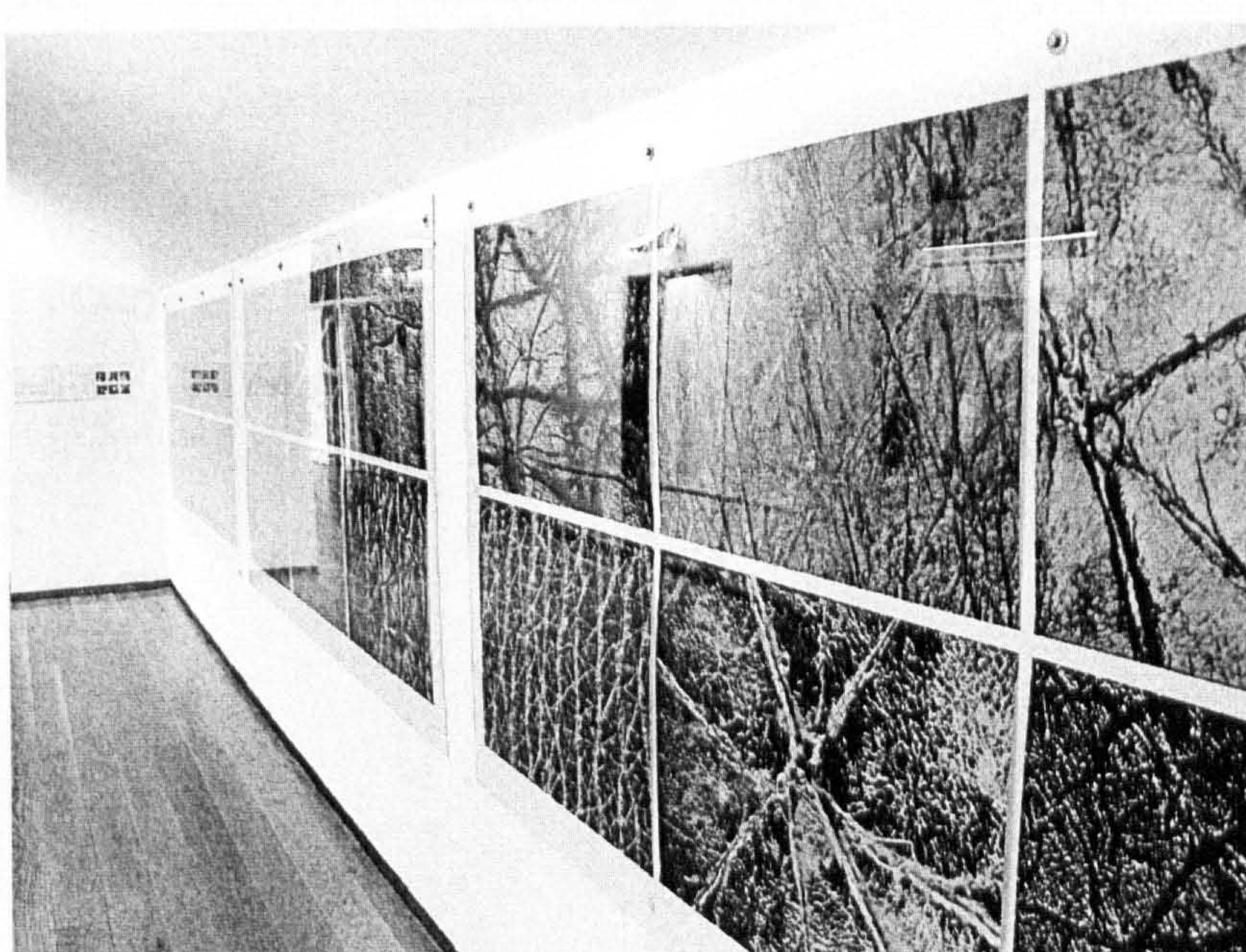


280, 281 A view from the PhD exhibition SKIN STORIES : CHARTING AND MAPPING THE SKIN, 2003, LCF MATERIAL'S CORNER.

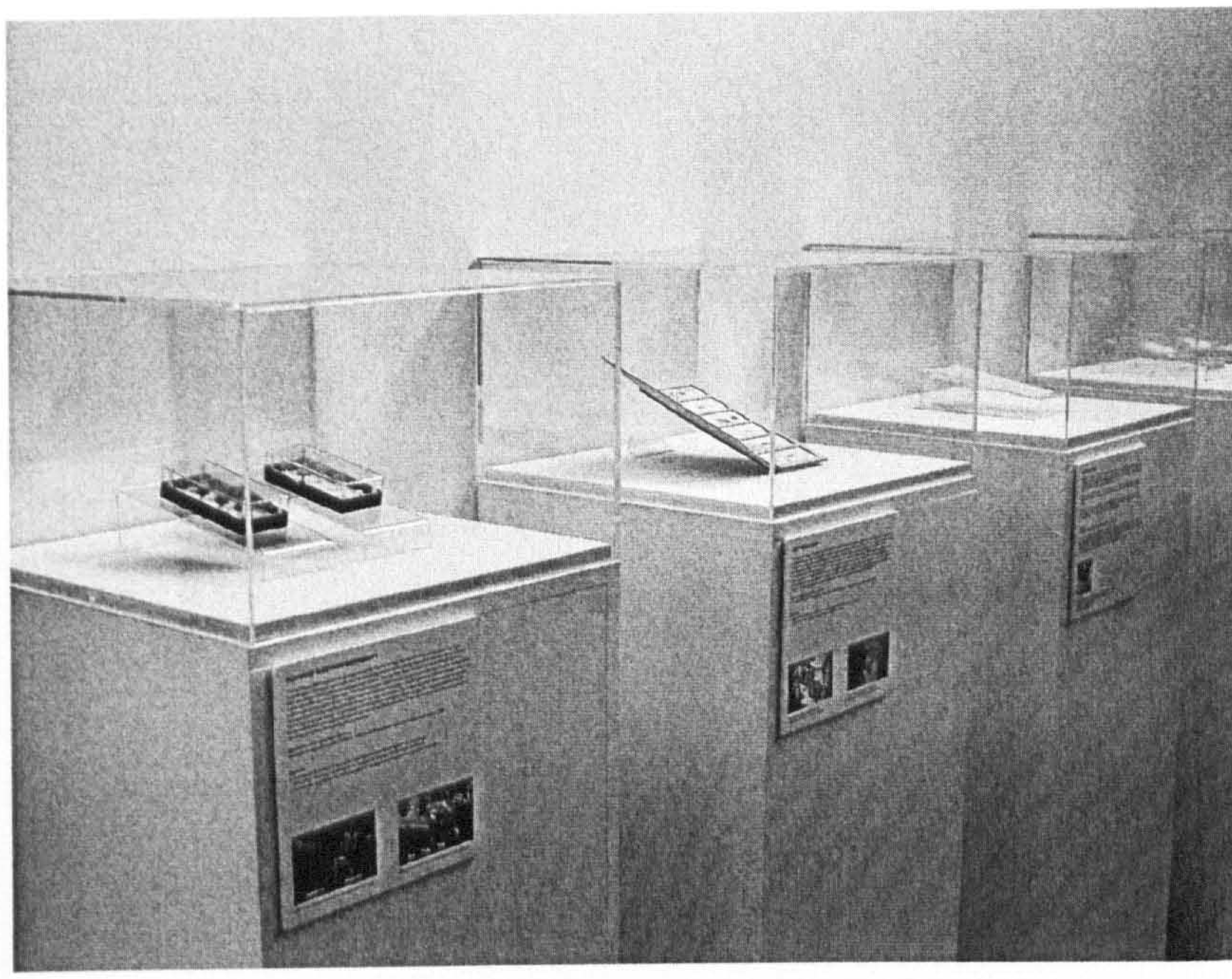


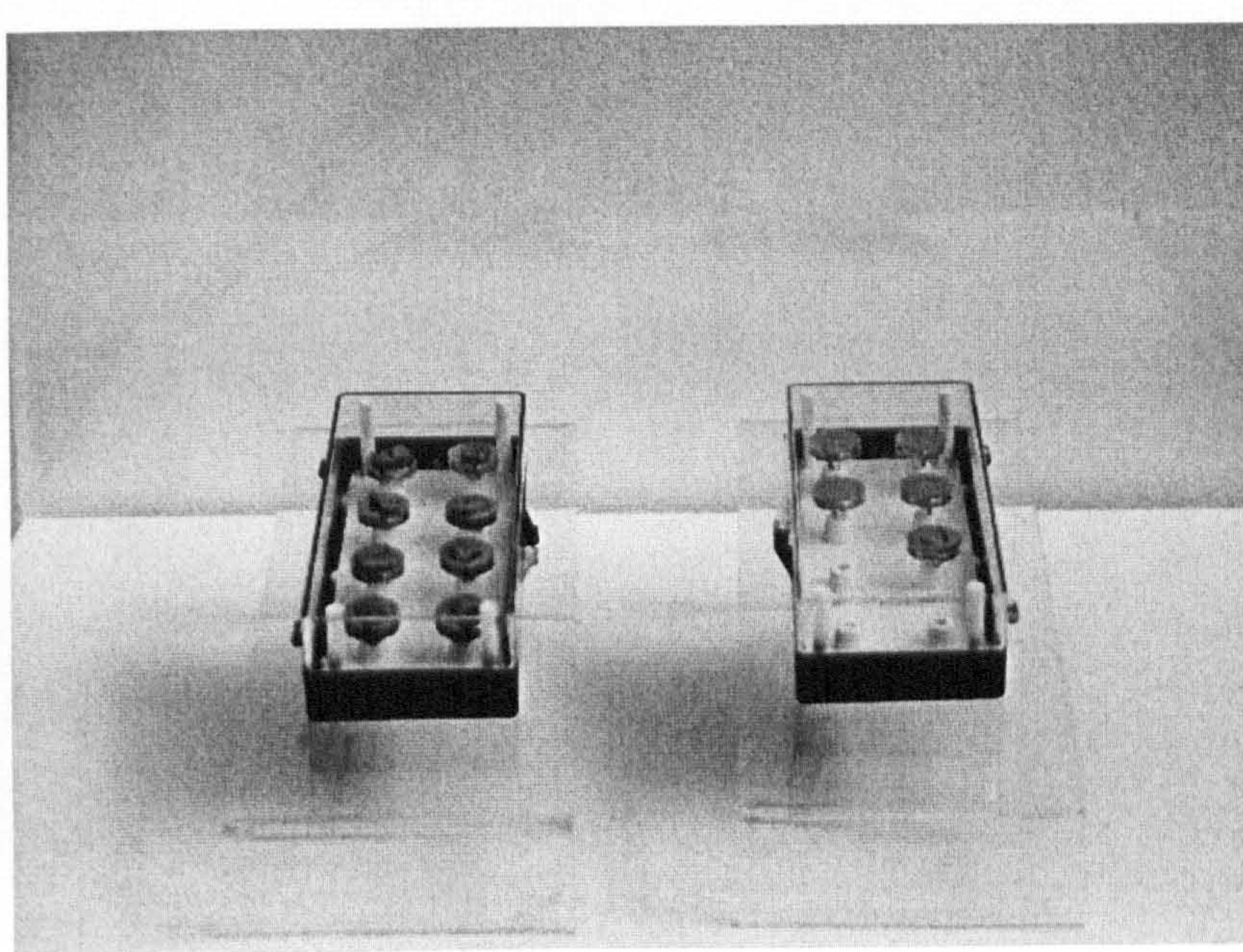


282, 283. A view from the PhD exhibition SKIN STORIES :: CHARTING AND MAPPING THE SKIN, 2003, LCF
SKIN CHARTS.

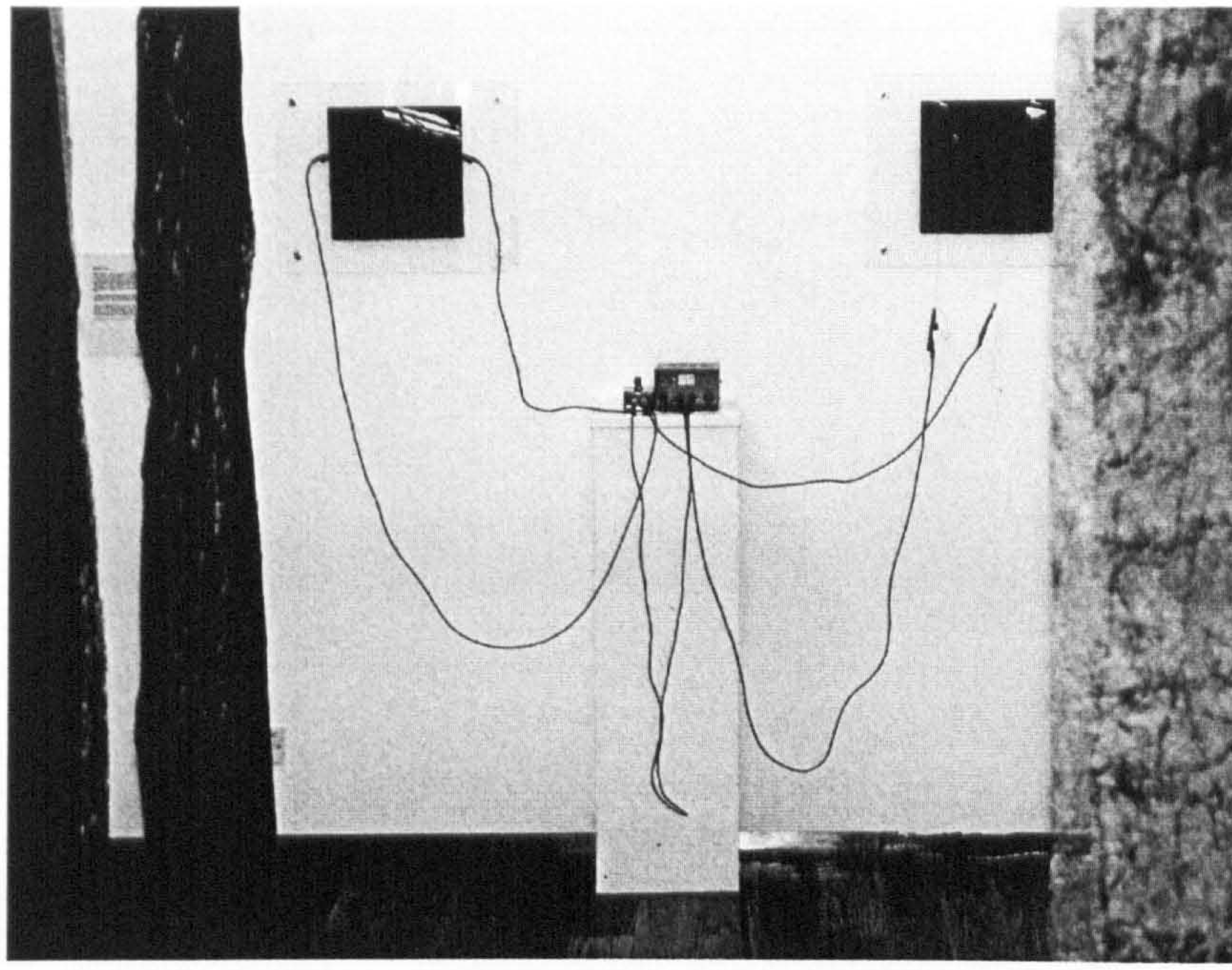


284, 285. A view from the PhD exhibition SKIN STORIES :: CHARTING AND MAPPING THE SKIN, 2003, LCF.
SKIN CHARTS.

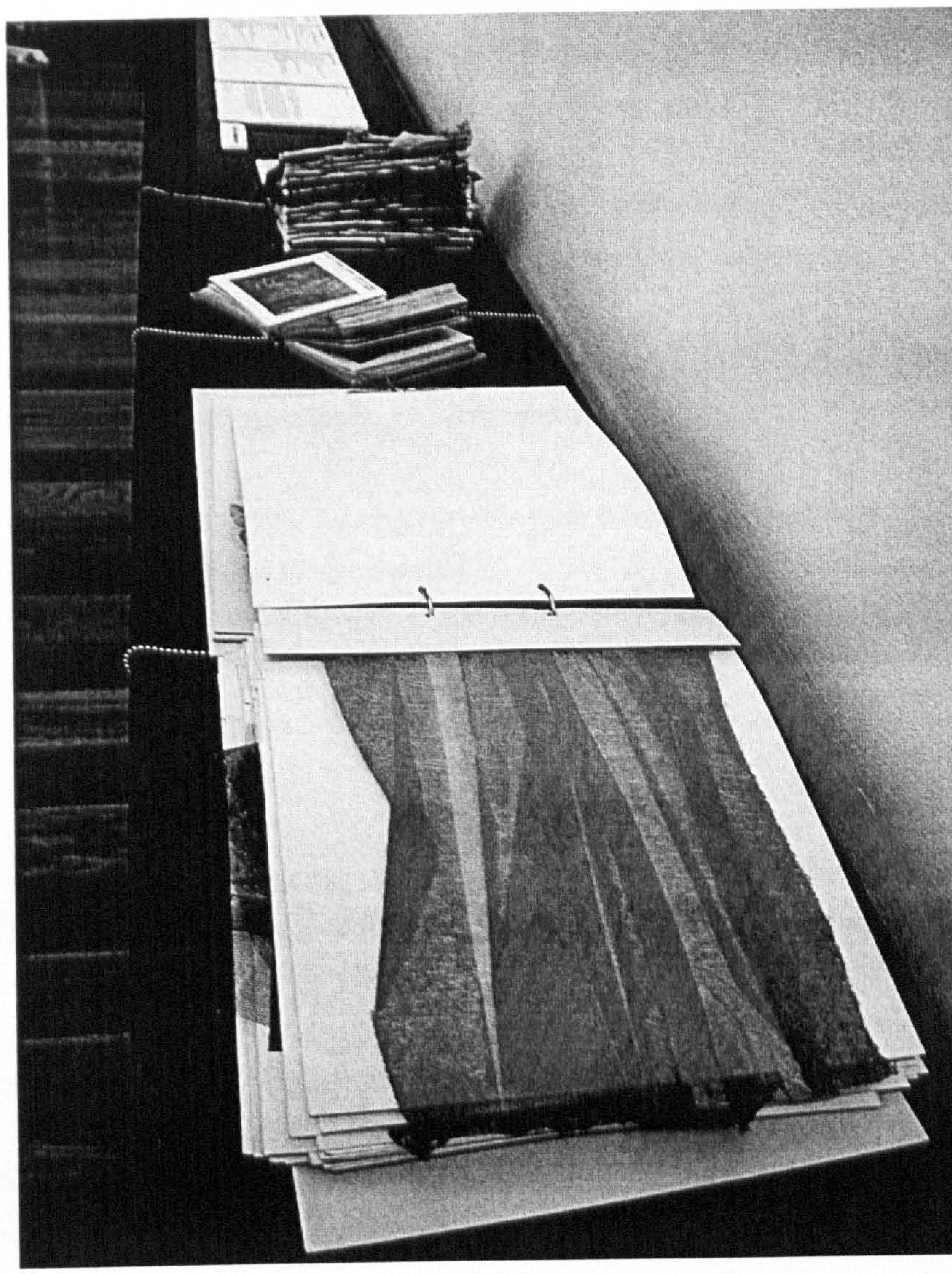




286, 287. A view from the PhD exhibition SKIN STORIES :: CHARTING AND MAPPING THE SKIN, 2003, LCF. BIOMEDICAL CORNER



288, 289 A view from the PhD exhibition SKIN STORIES :: CHARTING AND MAPPING THE SKIN, 2003, LCF



290 A view from the PhD exhibition SKIN STORIES :: CHARTING AND MAPPING THE SKIN, 2003, LCF.
LOG BOOKS.

The exhibition SKIN STORIES :: CHARTING AND MAPPING THE SKIN was documented in the form of analogue and digital photographs, and by making use of an audience response book to evaluate the outcome of the show and public reaction to it. Also numerous one-to-one interviews were conducted, which contributed to the process of evaluation. The following are questions I wanted to get responses to with some of the answers I received.

1 **What is your overall impression of electronic and interactive textiles?**

- Electronics + interactivity bring the textiles to life. They become more interesting. It's the future.
- It is our forthcoming reality being able to completely change our everyday life by bringing more joy, colours and senses to it.

2 **Would you personally be comfortable with electronic and interactive textiles within your environment?**

- Yes, but only if they were not too disturbing. They should be functional and enriching.
- I would; but the things should be chosen very carefully according to my needs.

3 **Aesthetics of electronic textiles: apart from the functionality, does it make a difference to you whether electronics are integrated within the structure of textiles visibly or invisibly?**

- Depends on a textile's purpose – for clothes, at the moment, it seems more interesting for everything to be invisible and not distracting.

4 **Do you think that similar concepts to Touch-Me Wallpaper (touch & smell textiles) and Living Screen (electronic textiles) would improve our environments?**

- This seems to be at an early stage but yes it definitely could – communication wise. A building that changes colour could be interesting.
- Yes. The aspect of interaction might even be curing. (I am an art therapist working with mentally ill people.)
- These 'alive' fabrics are interesting because they are 1) beautiful, 2) they can be used already as space dividers for interiors, architecture. Some of them are art pieces.

5 **What do you think in future environments the benefits might be of electronic and interactive textiles?**

- Amazing benefits – possibly as big as the mobile phone.
- A lot of benefits improving the quality of life.

6 **What do you feel the benefits would apply to?**

- Therapeutic, communication, safety.
- New esthetical understandings, psychological and physical healing, better dialogue between the resident and its environment.
- Some of these textiles seem to have the soothing qualities of a lit candle. Quietly soothing.

7 **Could you envisage buying these textiles?**

- Of course. I see a big market for them but they have to be more developed to become products.
- Yet not for myself but I can imagine them as an attractive and functional part of a public space.

Overall people were fascinated by this exhibition. They emphasised that they particularly enjoyed the 'successful unification of aesthetic and scientific research', 'the combination of scientific research, high technology and beautiful textile results' and the 'link between art and science'. Among the responses were also:

> 'The most fun that I had with my hands this week!'
>
> 'The work is a good mix of novel design aspects and added function'.
>
> 'I like the idea that our walls could serve as thermometers by changing colour in response to ambient heat.'
>
> 'I find this exhibition very beautiful and the integration of the technologies in textiles bring life and functionality into each piece.'
>
> 'The integrated technology, although at an early stage, offers much more then just a textile.'

CHAPTER 14 ::

SUMMARY OF THE RESEARCH OUTCOMES

14 SUMMARY OF THE RESEARCH OUTCOMES

'Truly therapeutic environments help close wounds and repair the body physically, mentally and emotionally.'[1] ***Richard Mazuch, healthcare architect***

Many things have led me to investigate more explicitly issues on, about and inside the skin. Among these are the professional habit of often treating fabric as a second skin, my previous research on bodily decoration practices and the semiotics of skin, as well as the currently shifting meaning of skin in the context of 21st century biotechnological reality. I have focused this practice led research project on the skin as an intelligent natural material on the premisse that it can serve as a model for new design solutions. I am exploring body and skin tissue in terms of biological chain reactions and mechanisms aiming to translate 'skin technology' into my textile practice. Despite my preoccupation with the technological and biomedical aspects I also constantly refer back to the poetic and social context of the epidermis, as it is important to me as a designer to capture the multi-layered nature of the skin issue.

The metaphor of dermis has been used to create innovative textile membranes embodying selected skin-like aspects specified in my research aims (Chapter 01). By translating and re-unifying these aspects in my creative textiles practice, during this project I have endeavoured to bridge the gap between aesthetics and technology as well as to develop interactive and therapeutic textiles for both the body and its various environments.

As a result of the research, based on a theoretical enquiry on multiple issues across the fields of art, design, technology, engineering, biology, biomimetics, science fiction, sociology and material science, investigations in biological labs and experimental work in textile studios, my interactive SKIN STORIES concept for a 2nd and 3rd skin has been modelled to a prototype stage. Our skin's naturally interactive and multifunctional 'technology' has informed this biomimetic design research by suggesting means by which the initial biological information might be best interpreted. For example, sensory information from the outer world gathered by the skin is sent to the brain in the form of electric impulses. This biological mechanism suggested the use of electric current in my work as the main stimulus for certain processes to take place and to corroborate the interactivity of the textile membranes.

While studying skin tissue as a model for intelligent design solutions, which involved technology-driven testing processes, I also become interested in the emotional aspects of the skin. Through more empirical experimentation I wanted to capture in my work the idea of the epidermis as a carrier of our very personal histories and identities, which are inscribed on our bodies in the form of lines, colour, scars, marks and blemishes. By creatively replicating these characteristics into new textile membranes I was linking certain skin properties to our psychological states. Furthermore, apart from the interactive qualities of the skin, I was aiming to capture its aesthetic and tactile properties, such as various surface patterns, smoothness or fleshiness, reflecting on the somatic aspects of dermis.

As a result of this research project I have developed a range of performance textiles that combine technologies currently commercially available with my expertise as a textiles designer. These employ three unique methods of production which I refer to as the VERSICOLOUR, the MULTICOLOUR CHROMIC DESIGN and the HEAT 'N SNIFF methods (Chapter 11) for applications in interactive textiles as demonstrated in the final textile prototypes and experimental samples. In addition to this, a wide range of aesthetic and functional design solutions have been established for inclusion in the SKIN STORIES concept. It is intended that these new mixed-media fabrics will provide textiles with active, interactive, sensory and protective properties for the body and our living environments. By enhancing our physical and psychological wellbeing and improving our sensory environments, these textiles will encourage people to explore their biological senses in novel ways. I consider these aspects of my research as my main contribution to new knowledge in the textiles field.

The public testing of this interactive textiles concept indicated that the audience and specialists were responsive to my work (Chapter 13) and that there is an encouraging potential for expansion on the results to date as suggested in Chapters 11 and 12. Further collaborations have already been planned in the near future and I have been invited to participate in the research network 'Haptic Technology, Interactive Textiles and Haptic Visuality', which links artists, engineers, computer scientists and psychologists within the UK and internationally.

Each individual work in SKIN STORIES carries an element of transformation. It metamorphoses from one material into another, from one state into another, referring to the skin as a living fabric of the body. In some way, our sense of self might feel diminished by seeing ourselves interpreted as nothing but enlarged skin structures, cells or nerve networks. I was interested in these as not just literal interpretations of initial images and functions of the dermis, but also in how they are associated to our various emotional states. For instance, an alarmed and distressed skin surface indicates anxiety just as the limbic network has to do with exchange, circulation, comfort and vitality and the nervous system stands for communication. The continual shedding of our epidermis reassures the renewal of our body.

14.1 OVERVIEW OF THE DESIGN PROCESS

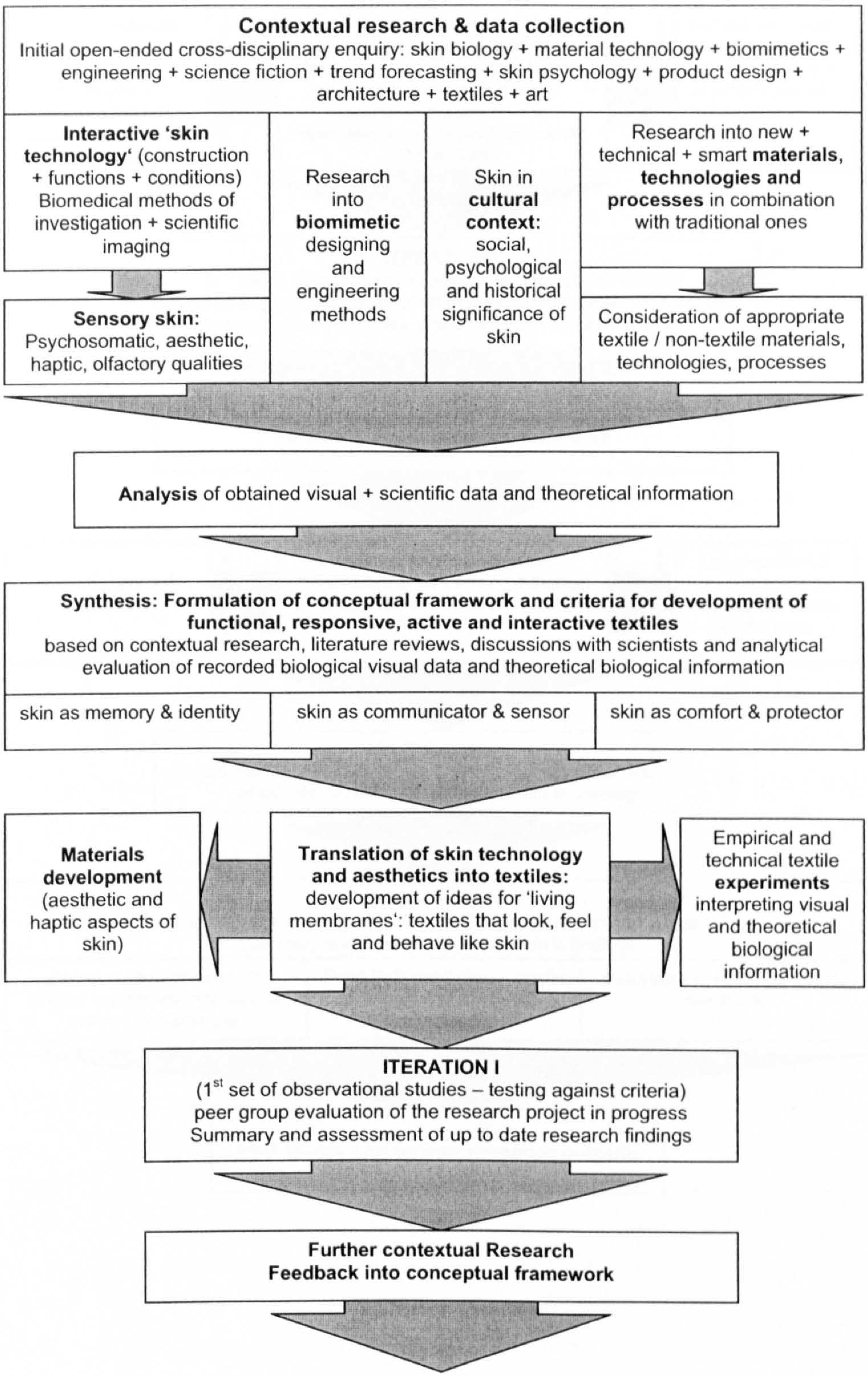
Through my practice led research process i have established a new methodology that other designers working at the interface between biology, material science, technology, engineering and textile design can consult and adapt for their work. Traditional design methodologies and product design models have been discussed by Nigel Cross[2] and Bruce Archer[3]. These have been consulted, modified and expanded through my practice-led research so that a new transferable model of design has been established as showed in Table 9.

The design process of the practice-led research project Skin Stories :: Charting and Mapping the Skin was informed and developed by combining and synthesising expertise, research methods and technological knowledge from divergent industries into a cross-disciplinary design approach.

Firstly, for the formulation of a design concept framework, **contextual research*** and **data collection** was conducted. It was an open-ended cross-disciplinary enquiry that drew on insights from skin biology, material technology, biomimetic design methods, engineering, science fiction, trend forecasting, skin psychology, product design, art practices, architecture, traditional, technical and smart textiles.

This investigation was particularly focussed around the **interactive 'skin technology'** (skin construction, its functions and conditions) employing biomedical methods of examination (Chapter 04) including data recording through the use of scientific imaging systems. A special method for collecting negative skin replicas from donors of various ages, genders and races was established for further case studies (Chapter 08). The analyses of the complex workings of the skin tissue lead me to the understanding of the **sensory skin** mechanisms and its psychosomatic, aesthetic, haptic and olfactory qualities and informed my textiles practice. Research into **biomimetic** designing and engineering methods allowed me to draw parallels with other design concepts that were based on studies of natural structures and mechanisms (07.2). Research into new, technical and smart **materials, technologies and processes** in combination with traditional ones informed my selection of appropriate textile / non-textile materials, technologies and processes for inclusion in the design concept (Chapter 07, 10). Furthermore, by placing the skin in its **cultural context** I was able to interpret the social, psychological and historical significance of the skin in my work (Chapter 03).

* bold type relates to the design methodology chart shown in Table 9


Contextual research & data collection
Initial open-ended cross-disciplinary enquiry: skin biology + material technology + biomimetics + engineering + science fiction + trend forecasting + skin psychology + product design + architecture + textiles + art
Interactive 'skin technology' (construction + functions + conditions) Biomedical methods of investigation + scientific imaging
Sensory skin: Psychosomatic, aesthetic, haptic, olfactory qualities
Research into biomimetic designing and engineering methods
Skin in cultural context: social, psychological and historical significance of skin
Research into new + technical + smart materials, technologies and processes in combination with traditional ones
Consideration of appropriate textile / non-textile materials, technologies, processes
Analysis of obtained visual + scientific data and theoretical information
Synthesis: Formulation of conceptual framework and criteria for development of functional, responsive, active and interactive textiles
based on contextual research, literature reviews, discussions with scientists and analytical evaluation of recorded biological visual data and theoretical biological information
skin as memory & identity
skin as communicator & sensor
skin as comfort & protector
Materials development (aesthetic and haptic aspects of skin)
Translation of skin technology and aesthetics into textiles: development of ideas for 'living membranes': textiles that look, feel and behave like skin
Empirical and technical textile experiments interpreting visual and theoretical biological information
ITERATION I
(1st set of observational studies – testing against criteria)
peer group evaluation of the research project in progress
Summary and assessment of up to date research findings
Further contextual Research
Feedback into conceptual framework

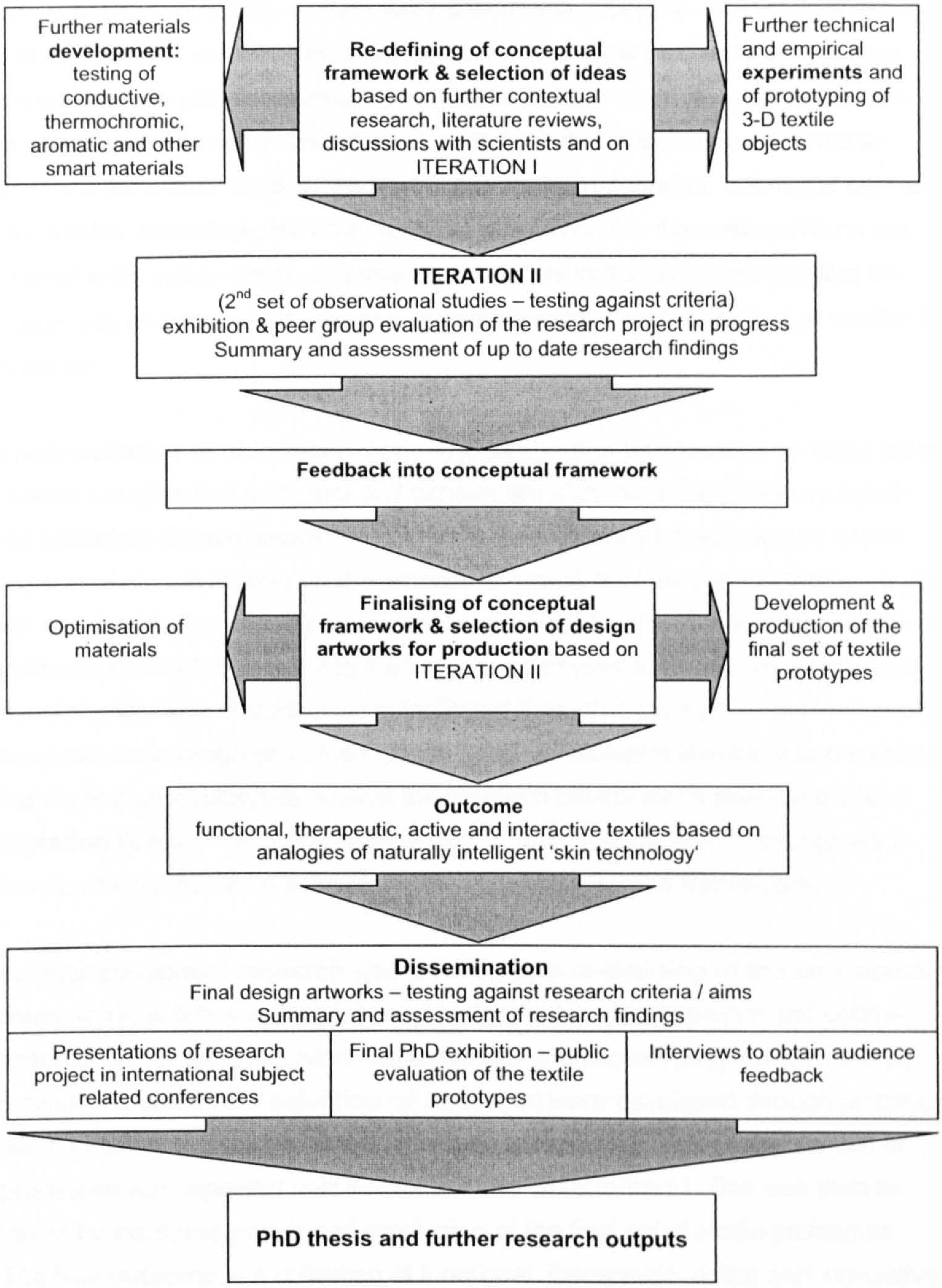


Table 9
Research methodology, transferable design model

The initial cross-disciplinary enquiry was followed by an **analysis** of the obtained visual and scientific data as well as the theoretical information based on contextual research, literature reviews and discussions with scientists. This was then followed by **synthesis** of the acquired information that informed the **formulation of the conceptual framework** and the **criteria for development of functional, responsive, active and interactive textiles.** Accordingly, the entire research was divided into three main sections that referred to the selected main characteristics of dermis for translation into a textiles language: skin as memory & identity, skin as communicator & sensor and skin as comfort & protector.

The **translation of skin technology and aesthetics into textiles** or 'living membranes' - textiles that look, feel and behave like skin - was supported by practical **materials development** trying to achieve the desired aesthetic and haptic aspects of skin. Furthermore the process of 'translation' was supported by empirical and technical textile **experiments** interpreting visual and theoretical biological information, which evolved into the first pre-prototypes for a first set of observational studies. These studies were facilitated through a peer group evaluation of the research in progress at the London Institute Research Seminars and by testing the first pre-prototypes against the research criteria for its skin-like qualities **(iteration I)**. A summary and assessment of up to date research findings were made, which provided **feedback** for the initial **conceptual framework.**

Further contextual research was followed by a **re-defining of the conceptual framework,** which was then followed by the further **development** and optimisation of materials used. More **experiments** and **prototyping** led to repeated evaluations and a new **selection of ideas** that were developed through prototype testing against the original research criteria **(iterations)**. This circle or chain of processes was repeated until suitable results were reached. This was then followed by the development and production of the final set of textile prototypes. The final **outcome** is a collection of functional, therapeutic, active and interactive textiles and textile installations based on analogies of naturally intelligent 'skin technology'.

Finally, a **dissemination** takes place and the final design artworks are again getting tested against research criteria and aims. This was done through the presentation of the research project at international subject related conferences and by public evaluation of the textile prototypes at the PhD exhibition, which included the conducting of interviews to obtain audience feedback (Chapter 13).

The body of work along with the entire practice-led cross-disciplinary research process, including the overview and assessment of the research findings are documented in my **PhD thesis**. The research leads also to **further research outputs** in the form of articles, academic papers, exhibitions and current and future research collaborations.

14.2 CONCLUSION

My research project reflects on current developments within material research and technologies, their properties and their possible applications within design in combination with the more common textile materials and processes. It also contributes to cross-disciplinary activities in science, art and design and demonstrates how they might influence the cultural environment. My project evolved around explorations of the biological, medical and cultural characteristics of human skin tissue in order to create a solid framework for my creative practice. As a textile designer, I intended the practice to be the primary basis of my research project. The almost metaphysical procedures of experimentation with materials, techniques and electric current provided a certain 'magical' aspect to the entire research process. I would like to hope that the resulting design artworks, apart from their technological, intellectual, functional and aesthetic content, still carry a tiny part of that 'magic' which is hard to describe, access or measure using objective criteria.

Through my research project, involving scientists and engineers, as well as reviewing various bio-art practices, it was exciting to examine how scientific thought influences contemporary art and design practice and conversely how art and design has the potential to influence scientific thinking. I was particularly interested in the overlapping theoretical and practical aspects of charting and mapping the skin, which both continually informed and formed the entire research process. For me personally this project was a very enriching learning and work experience that gave me the possibility to generate, explore, develop and reflect on new design ideas, which now form the basis for further research.

I plan to expand on the research undertaken to date by developing and utilising it further in order to achieve a truly interactive environment for the future. To support this I intend to 'upgrade' the analogue systems to digital systems, which would enable more sophisticated textile displays and establish the skin/brain analogy, referring to the computer station as the 'brain'. This would allow me to continue hands-on investigations on a larger scale offering a wider range of design possibilities in terms of complexity and variety of latent patterns, colour combinations, rhythms of colourchange plays and aroma release. The incorporation of digital technologies would also enhance the interaction mechanisms between the human and the designed environment. It would improve the aspect of safety as well as increase the scope for potential applications.

I am personally fascinated by the potential of textiles to improve the quality of our lives. I would like to continue to investigate how environments can be enhanced using textiles as vehicles for information, interaction and sensory experiences, as well as how to develop new design solutions, thinking of future options. In connection with this I am also interested in the overall development in contemporary textiles as it moves closer to science. Today the issues of nano-technologies, tissue engineering and information technologies are increasingly blending with textile issues by opening new opportunities for designers and researchers.

Textiles are becoming fused with the body and in biomedical practices these are being used to design, replace and optimise the skin and other body tissues. Therefore, in the light of our (bio)technological reality, the often used analogy of textiles being our second skin is beginning to obtain a new meaning. My practice led research has raised these issues and I am curious to investigate them further. All these above-mentioned aspects are important to me both theoretically and practically. I see myself as a designer-mediator marrying technological and material innovation with real design applications in our environments.

Originally from Latvia, for me studies and work in western Europe mean immersing myself in quite another cultural context. I was fortunate to win two awards (ORS – The Overseas Research Students Award and The London Institute Scholarship) which gave me the opportunity to develop my PhD project at The London College of Fashion. In researching for my PhD I was given the possibility of fulfilling my professional needs using both my academic skills and up-to-date technologies in order to acquire new textile solutions. I aim to continue to develop my work from the traditional textiles media to an interdisciplinary realm of textile design in all its various guises.

My vital interest is to continue cross-disciplinary work in the research sector as a textile practitioner, actively collaborating with industry and research institutions. A cross-disciplinary approach offers virtually unlimited opportunities for new things to happen. Nowadays the boundaries of traditional disciplines are fading and amazingly we discover again and again new ways of doing previously impossible things based on the progress of science, technology and most importantly – on creative thinking. I try to work with this as my guiding principle.

14.3 RESEARCH OUTPUT AND DISSEMINATION

The following articles have been published in relation to my research project:

March 2004	**Textile Magazine** No 2 Textile Institute News (UK)
March 2004	Design Magazine **Centras** Review on Skin Stories Exhibition in London (Lithuania)
Jan. 2004	Magazine **Future Materials**, Skin Stories Wallcovering (UK) available from: www.inteletex.com/FrontPageNews.asp?PubId=&NewsId=2547
#4 July 2003	Magazine **Mikrokosmos** (Germany) Hautgeschichten – Skin Stories
#1(45) / 2003	Magazine **Latvijasarchitektura** (Latvia) Inteligentais tekstila dizains (Intelligent Textile Design)
Feb. 2003	Publication - **ballettanz** Magazine (Germany) Topography of Skin
Since 2002	www.skinstories.com

The following features my PhD work being presented for public review in various exhibitions:

2004	'Insane about the Membrane' Gallery of the University of Brighton, UK
2003	'Skin Stories :: Charting and Mapping the Skin' (poster presentation) Conference Material_Vision, Frankfurt/M, Germany
2003	'Skin Stories :: Charting and Mapping the Skin' (solo exhibition) Fashion Space Gallery, London College of Fashion, LINST, UK
2003	'Artists at Work: New Technology in Textile and Fibre Art' (catalogue) International exhibition at the Textile Museum of Prato, Italy
2003	Adaptation – Contemporary Latvian Art Now (catalogue) The Art Museum of Estonia
2002	'Topography of Skin' (solo exhibition) Gallery ACUD, Berlin, Germany
2002	International Biennial Design (catalogue) Saint-Etienne, France

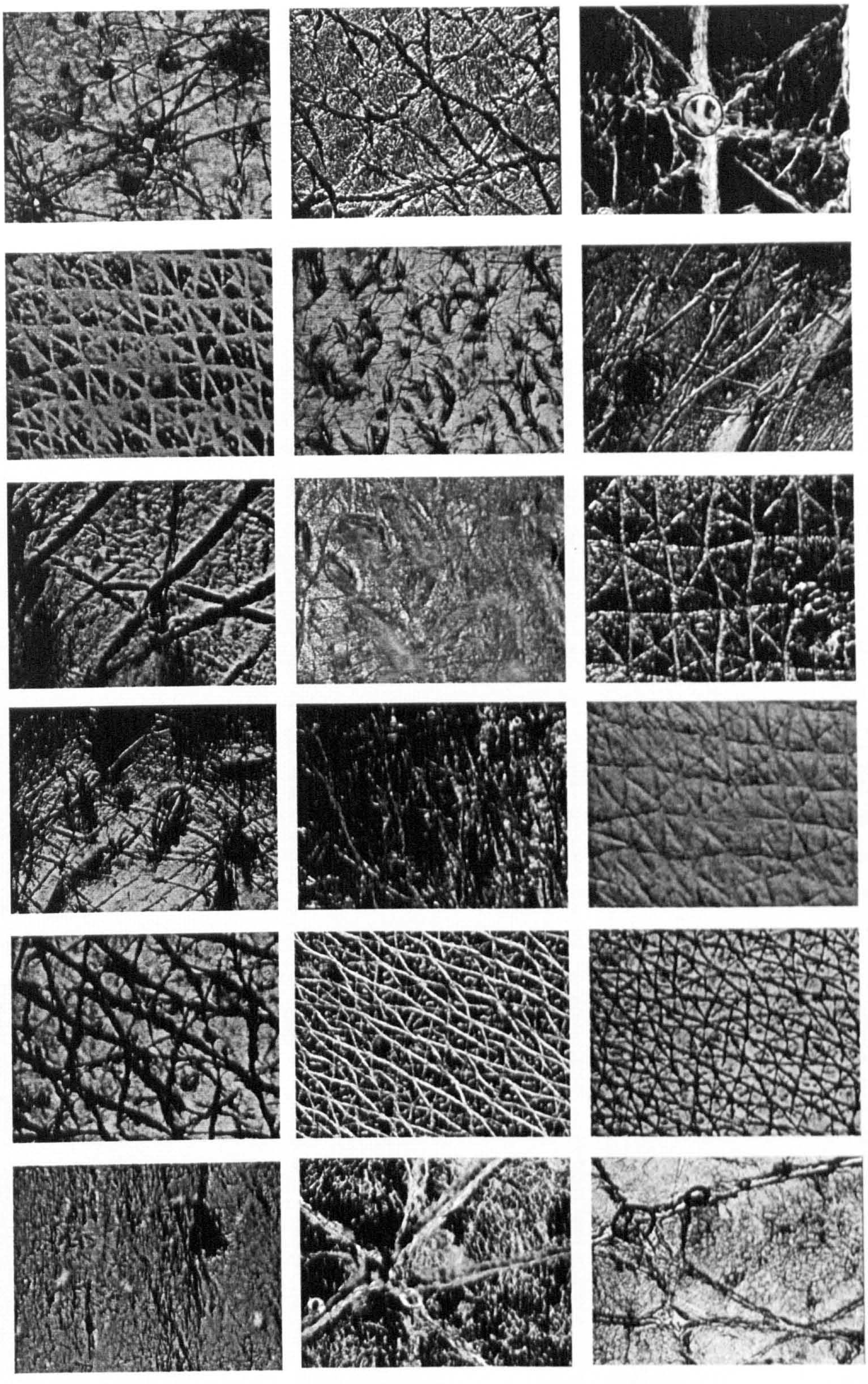
APPENDICES

APPENDIX A – ZOOM IN GALLERY

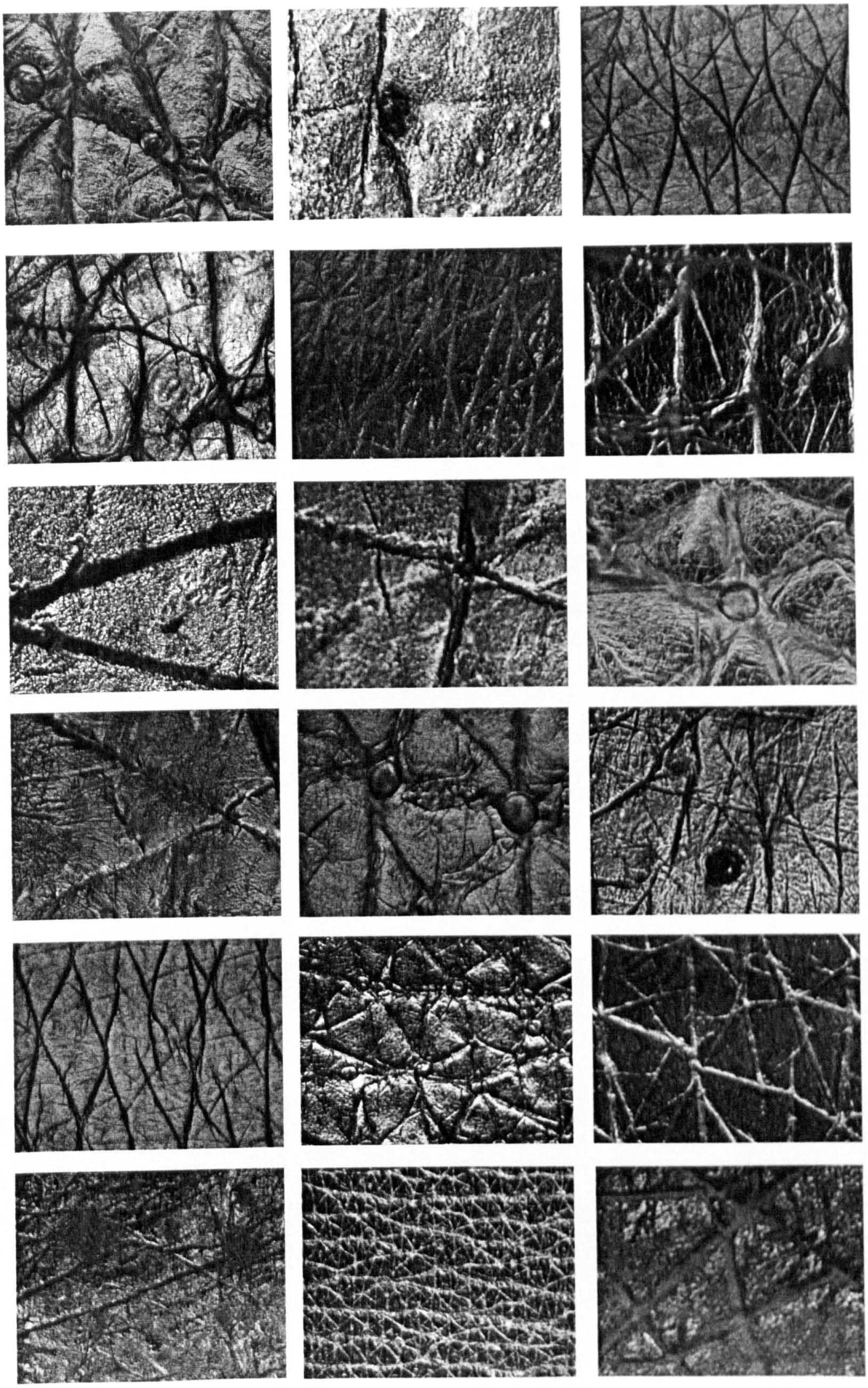
The micrographs taken at the Institute for Biology and Zoology, Free University in Berlin, reveal the astonishing beauty of skin and patterns invisible to the naked human eye. Photomicrographs were obtained using advanced microscopic imaging technologies such as the light microscope. Referring to the nature of the skin specimens used for the investigation, all micrographs are classified into two series: Skin Surface and Skin Architecture.

For the series Skin Architecture, medically prepared skin specimens were used which are tiny slices of skin. This invasive method allows scientists to examine the structures and functions of the epidermis and to have a panoramic view on the skin's interior. The medical skin slides used for my investigations were borrowed from the Beauty Treatment Department at the LCF with the kind permission of Dr. Tamburic Danka.

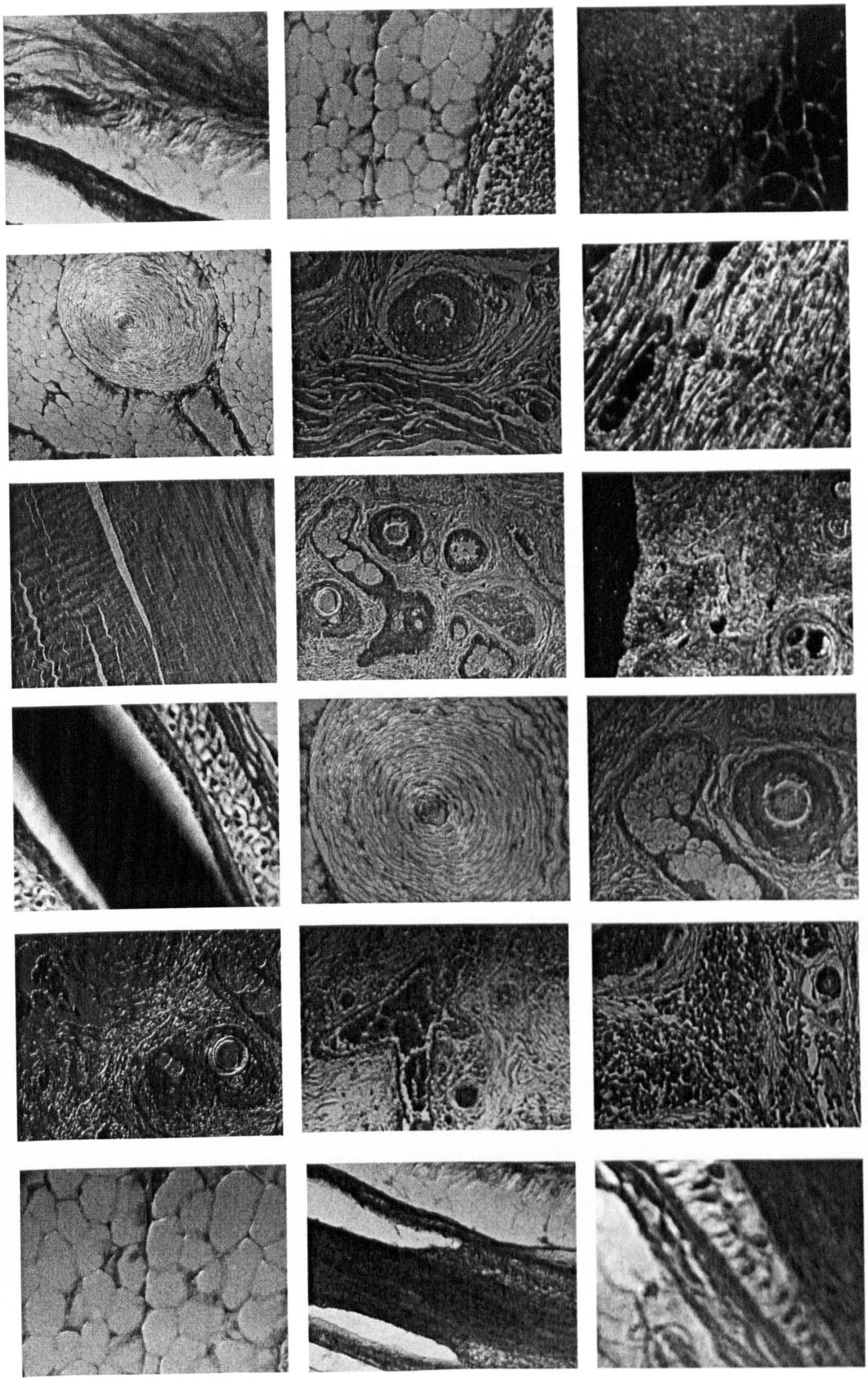
For the series Skin Surface, casts of the surfaces of the epidermis from various volunteer donors were prepared by myself. Using this method I was able to analyse and to compare the surfaces of different people's skin; people of different race, age and gender. For reference purposes I have taken a Polaroid photo of each person who has donated a skin cast.



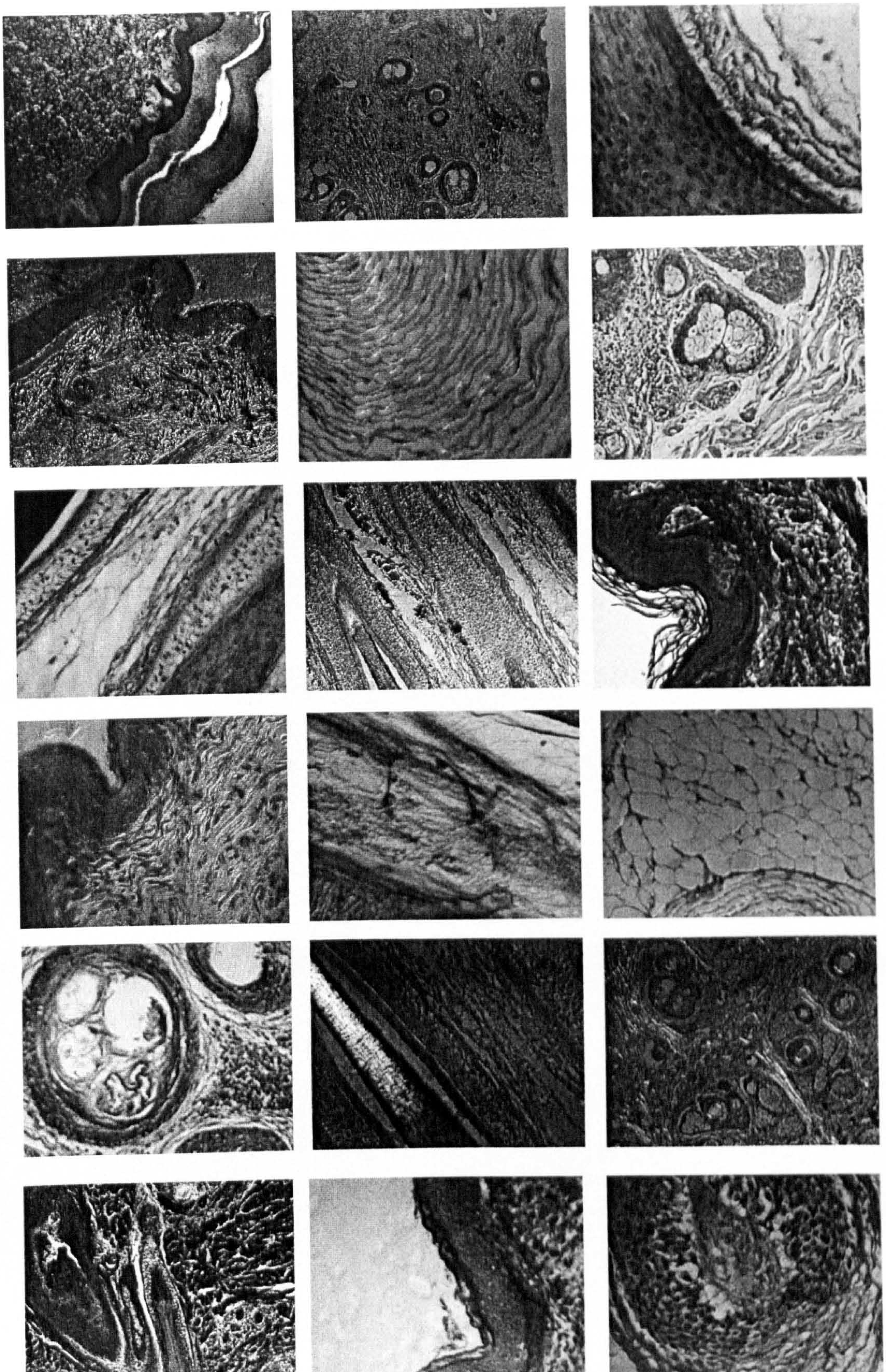
291 A. ZOOM IN GALLERY ., TOPOGRAPHY OF SKIN, light micrographs, 2002
Image library, selected micrographs of skin surfaces obtained from volunteer donors.



291 B ZOOM IN GALLERY = TOPOGRAPHY OF SKIN, light micrographs, 2002
Image library: selected micrographs of skin surfaces obtained from volunteer donors



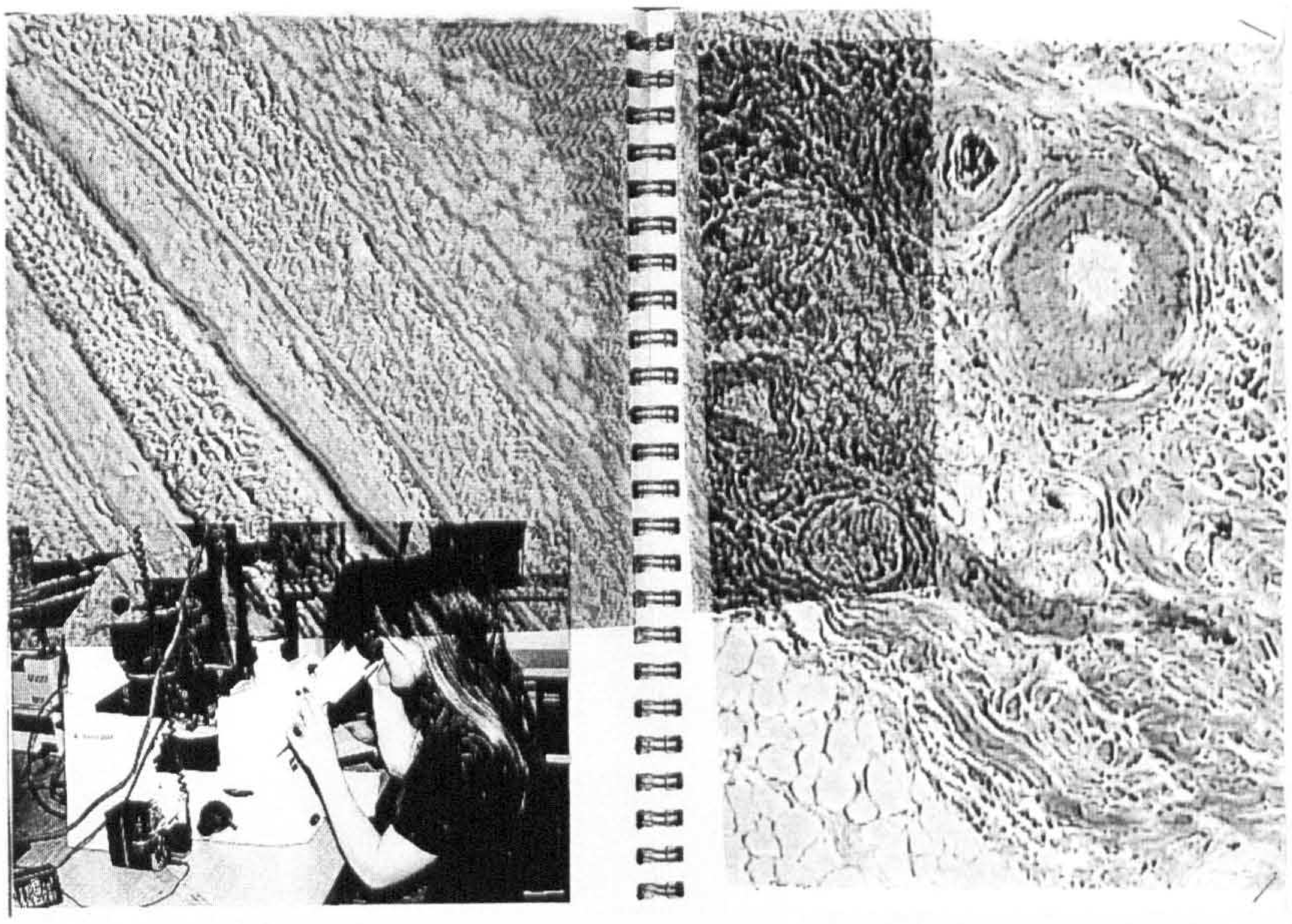
292 A ZOOM IN GALLERY – ARCHITECTURE OF SKIN, light micrographs
image library, selected micrographs of skin structures

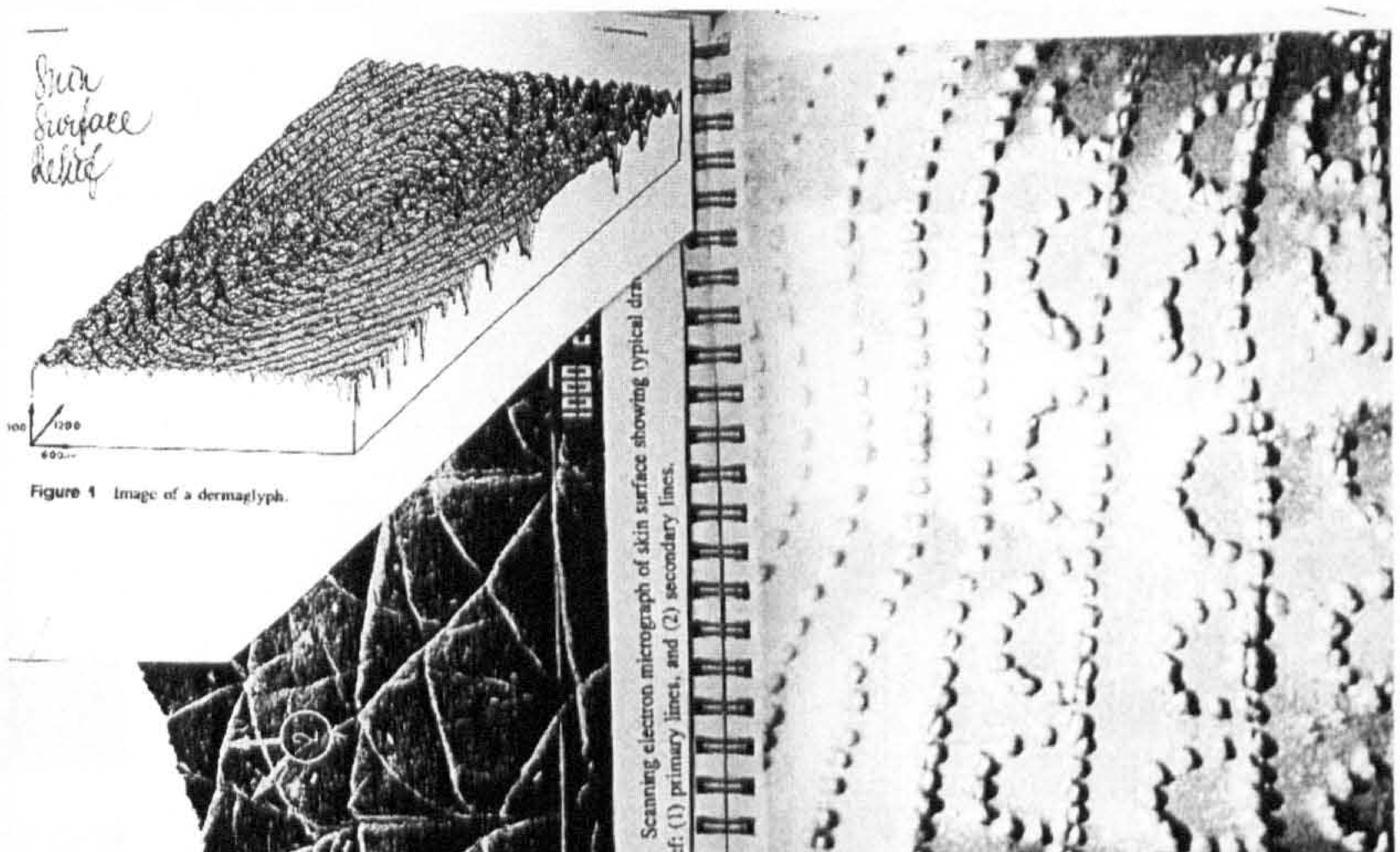


292.B. ZOOM-IN GALLERY :: ARCHITECTURE OF SKIN, light micrographs
Image library, selected micrographs of skin structures

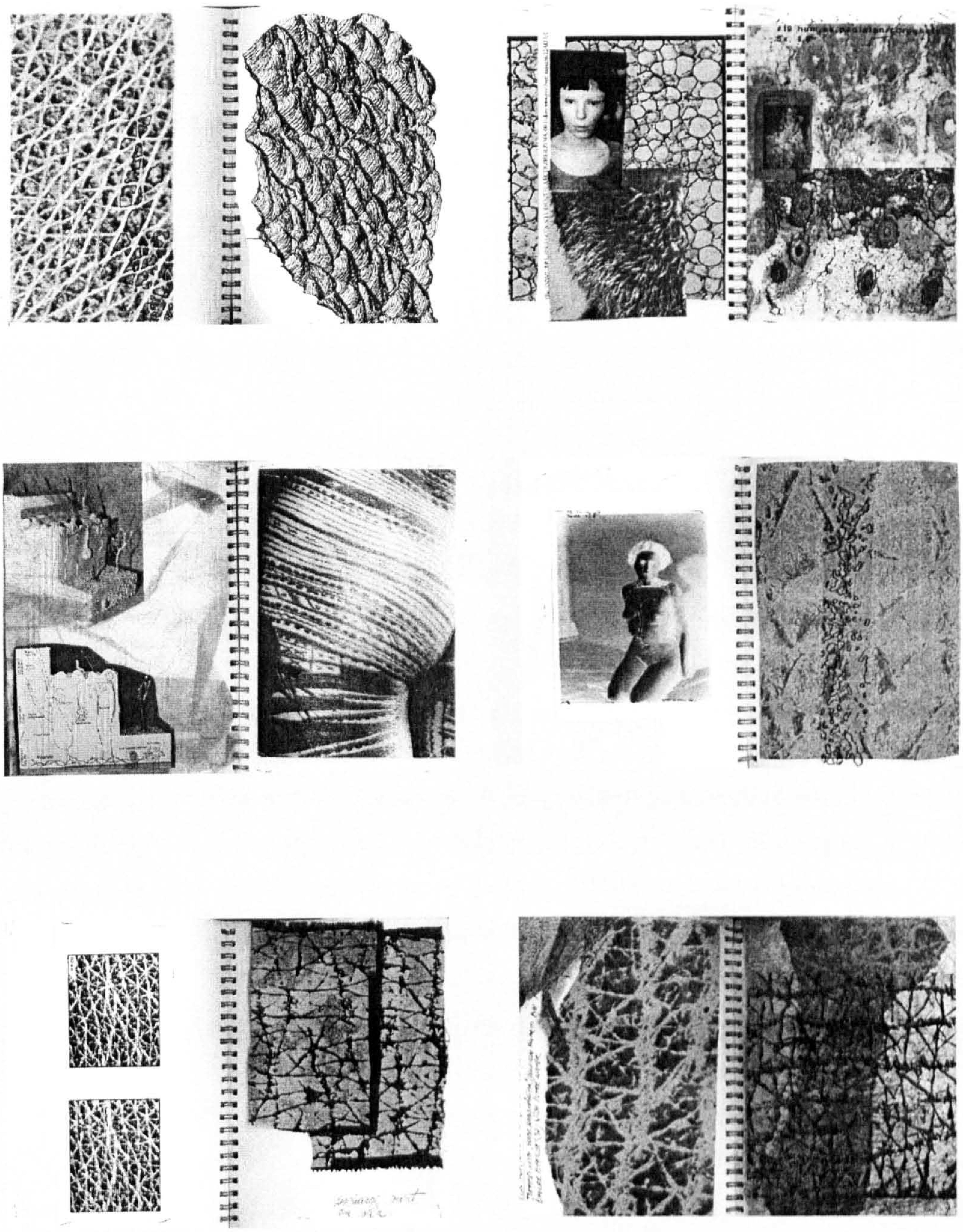
APPENDIX B – HIGHLIGHTS FROM THE LOG BOOKS

During the entire research my creative and analytical thought processes were recorded in my sketch/note books. This method enabled me to produce an interesting visual evidence for the empirical research process and provided my practical design work with fresh ideas. It also has been the main tool used for the unification of the aesthetic and scientific aspects of my interdisciplinary research.

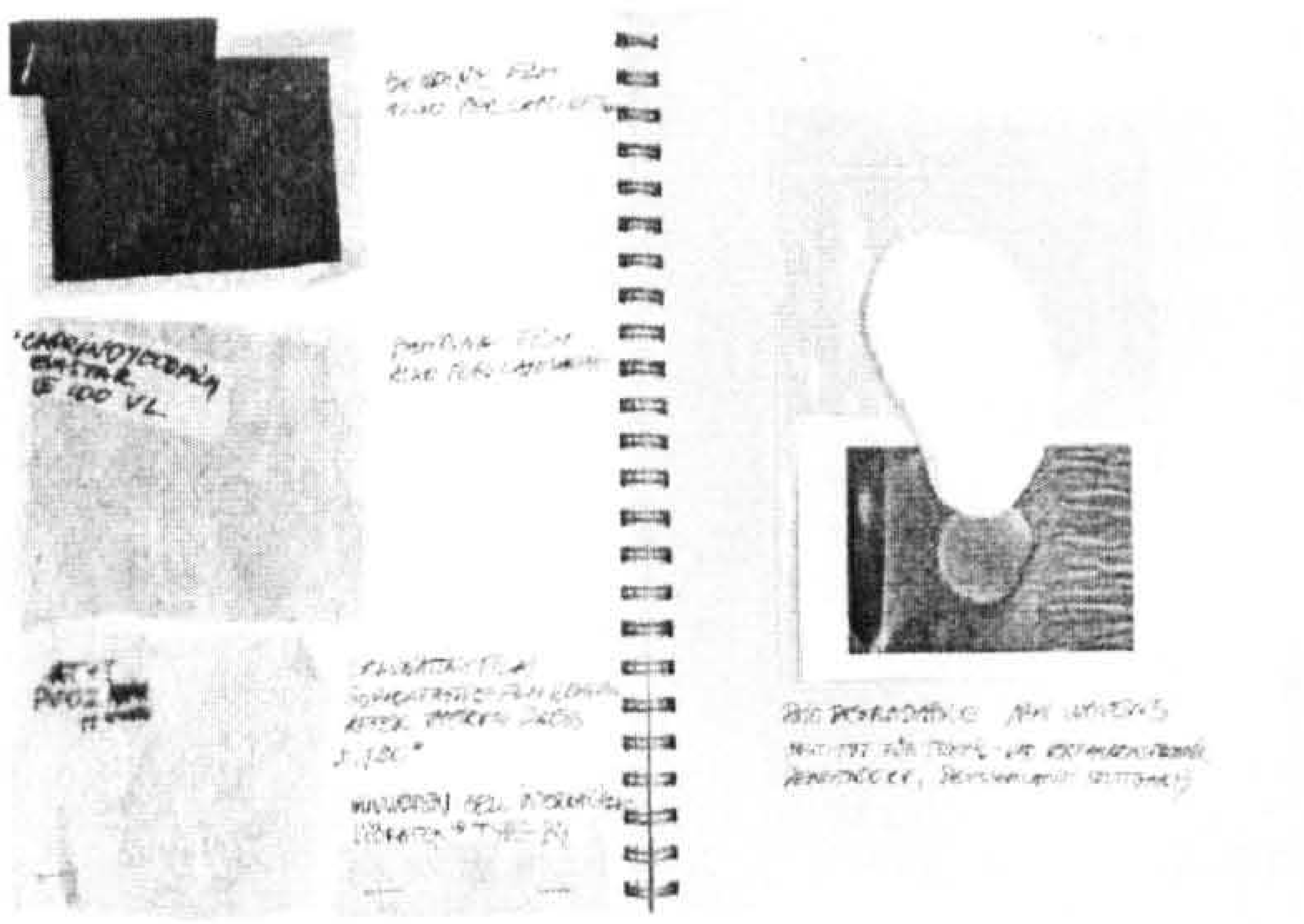


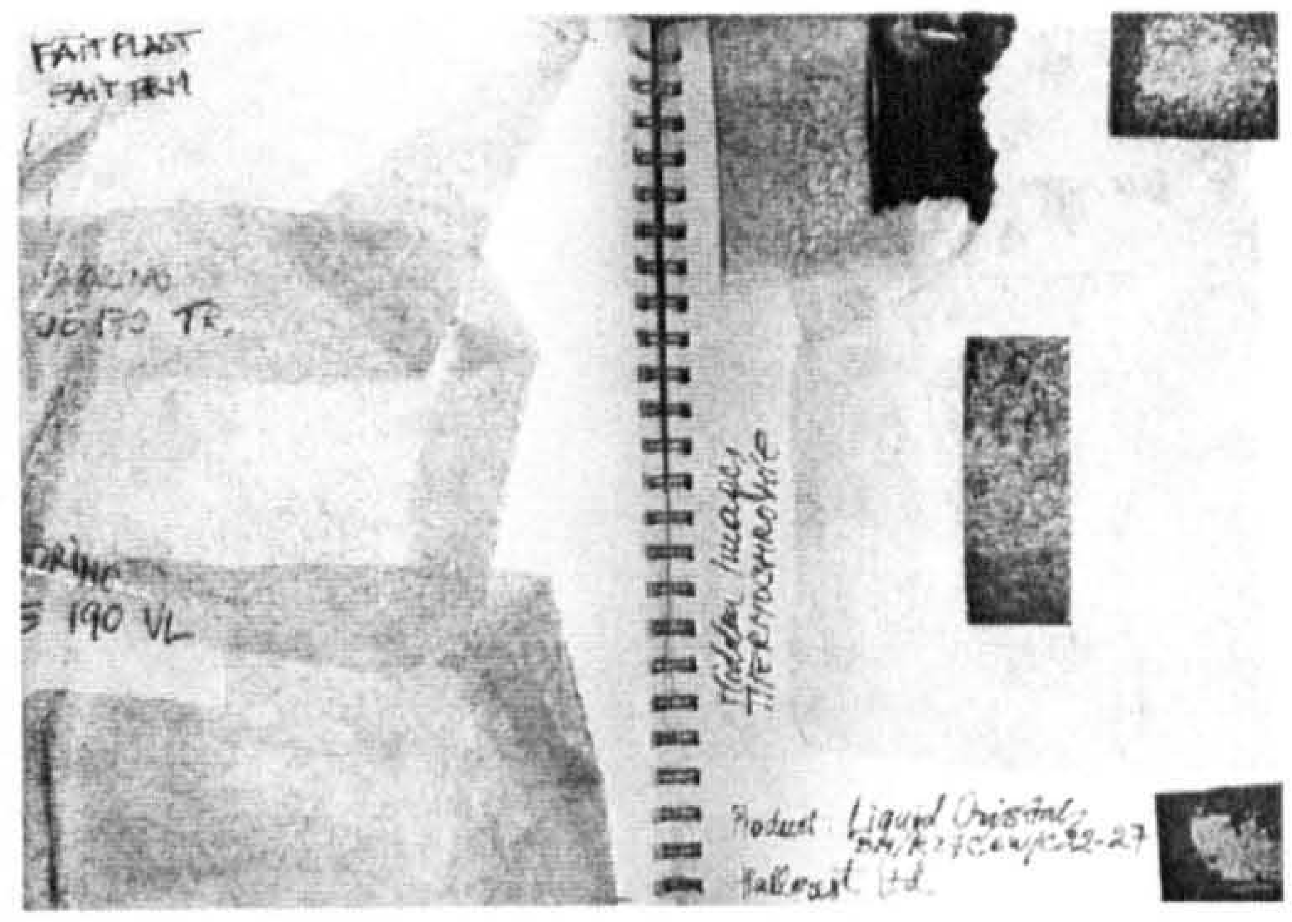


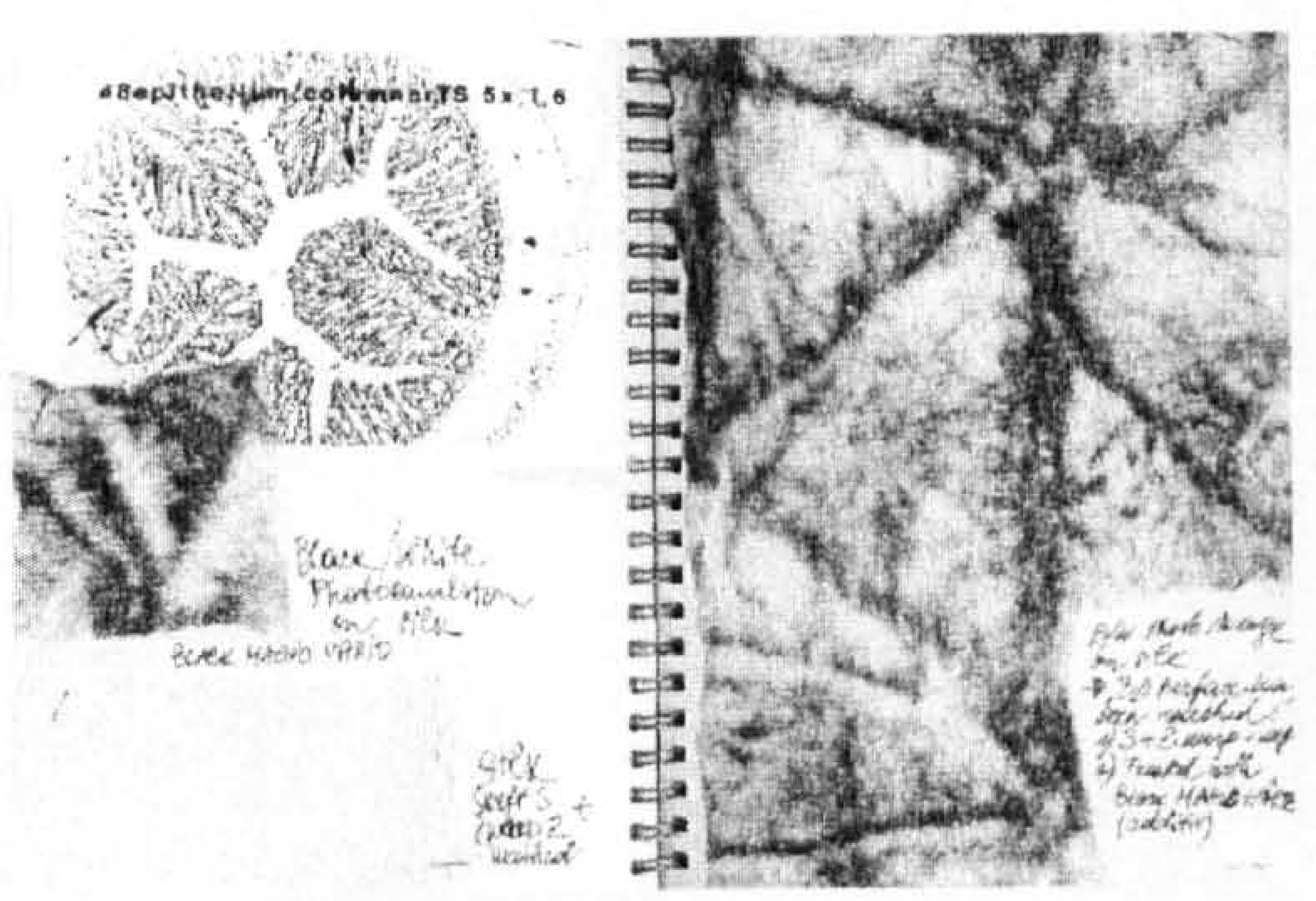
293 A, B Log books.
Selected images.

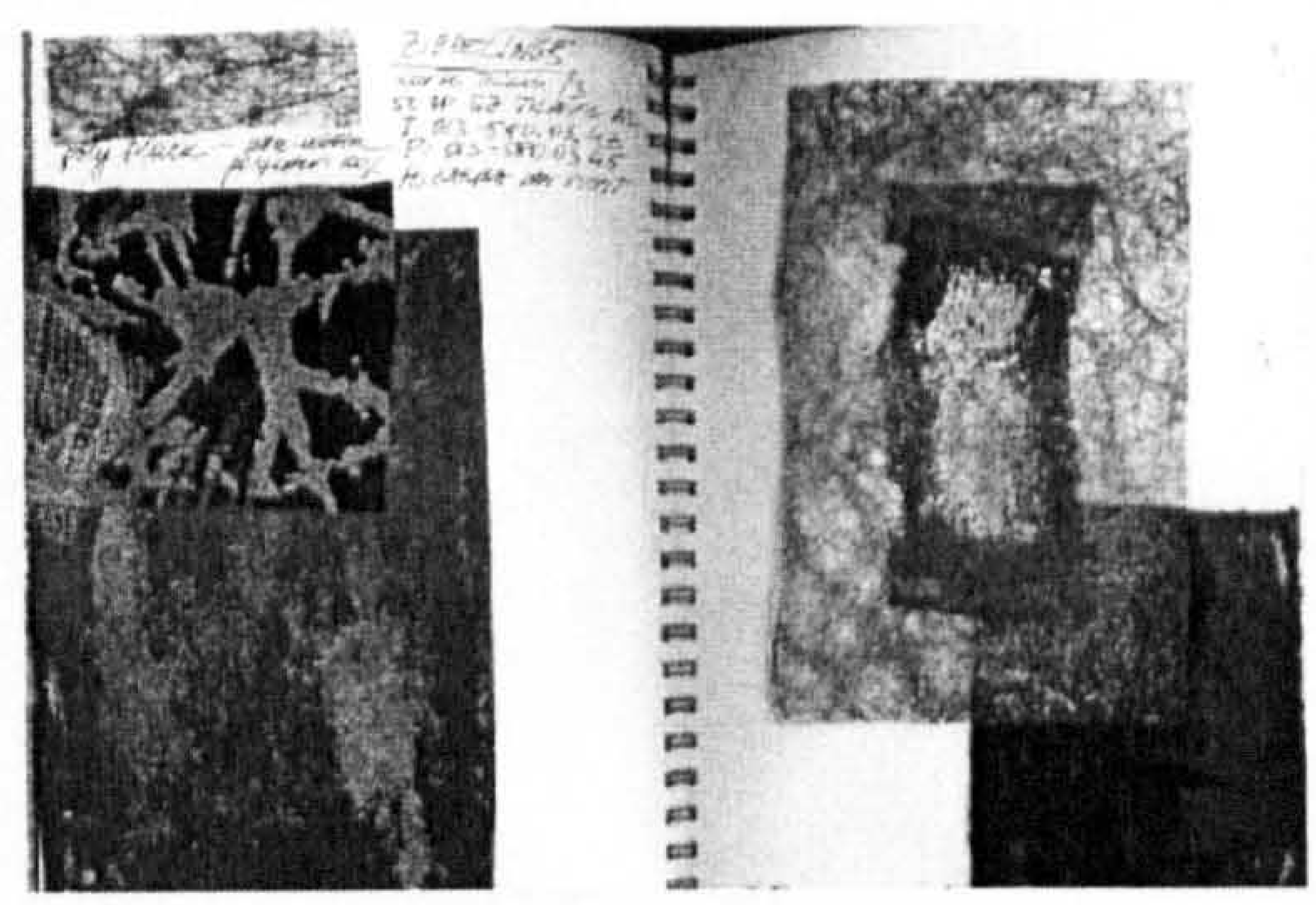


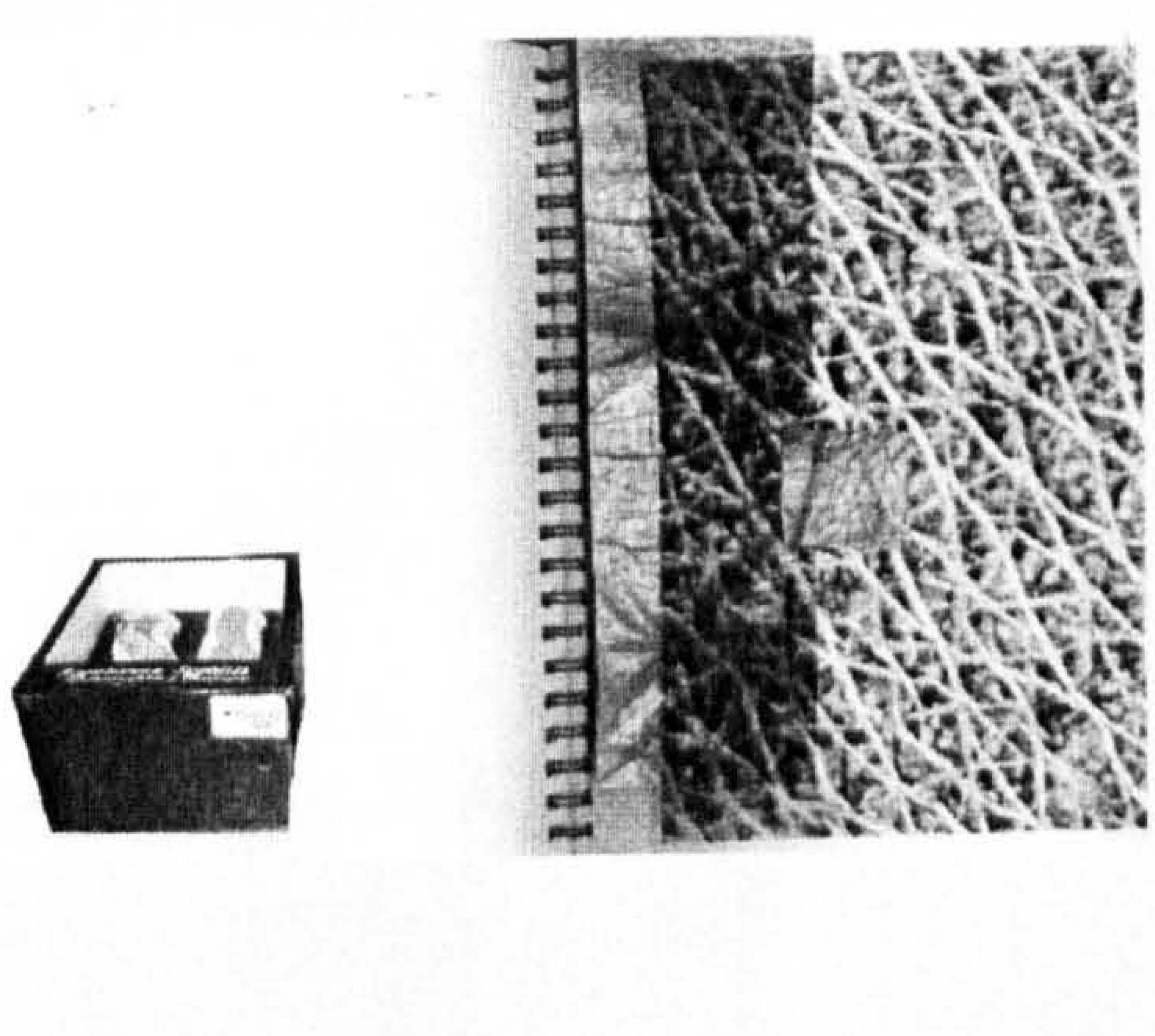
294 A, B, C, D, E, F Log books.
Selected images.



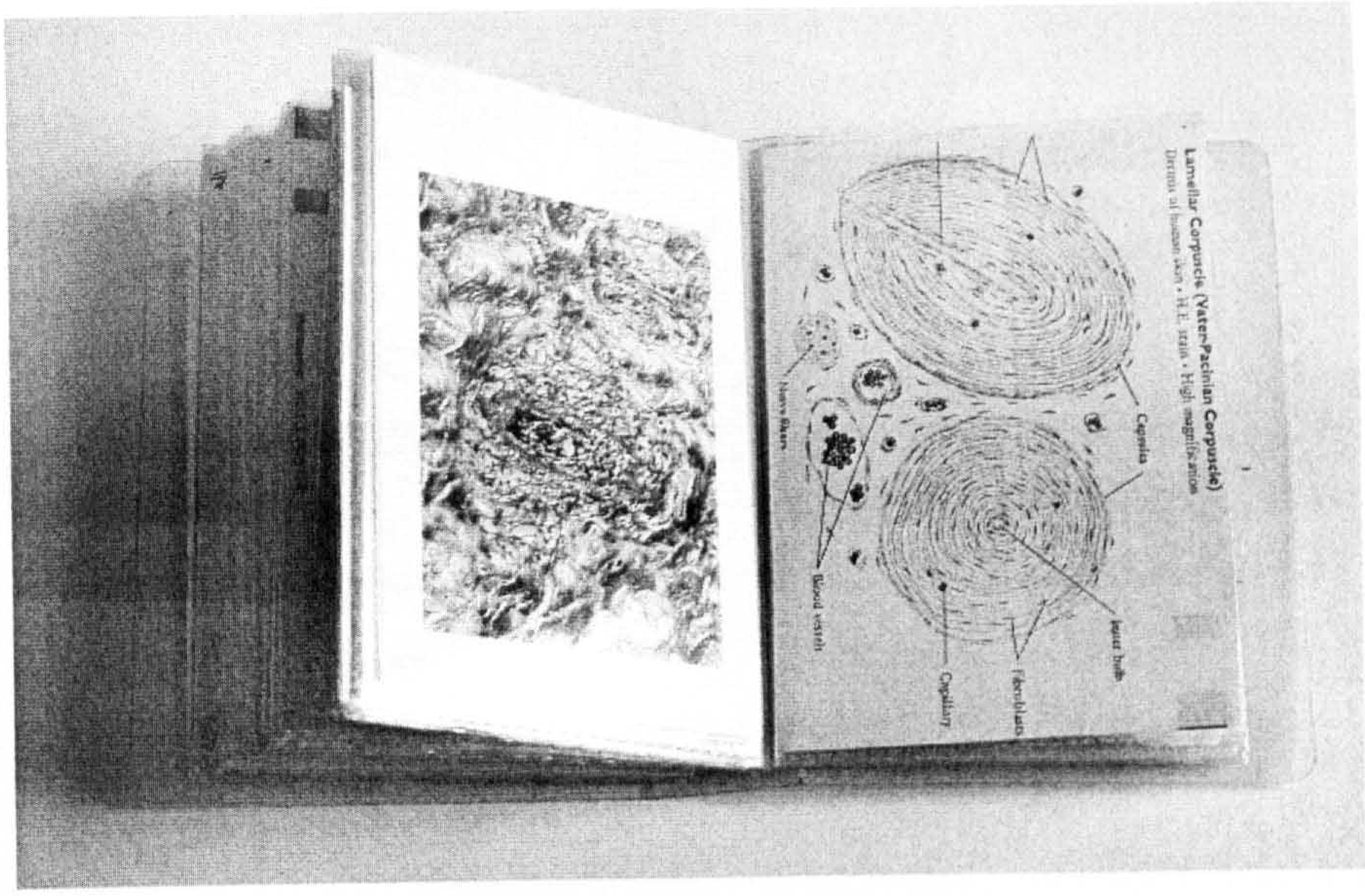


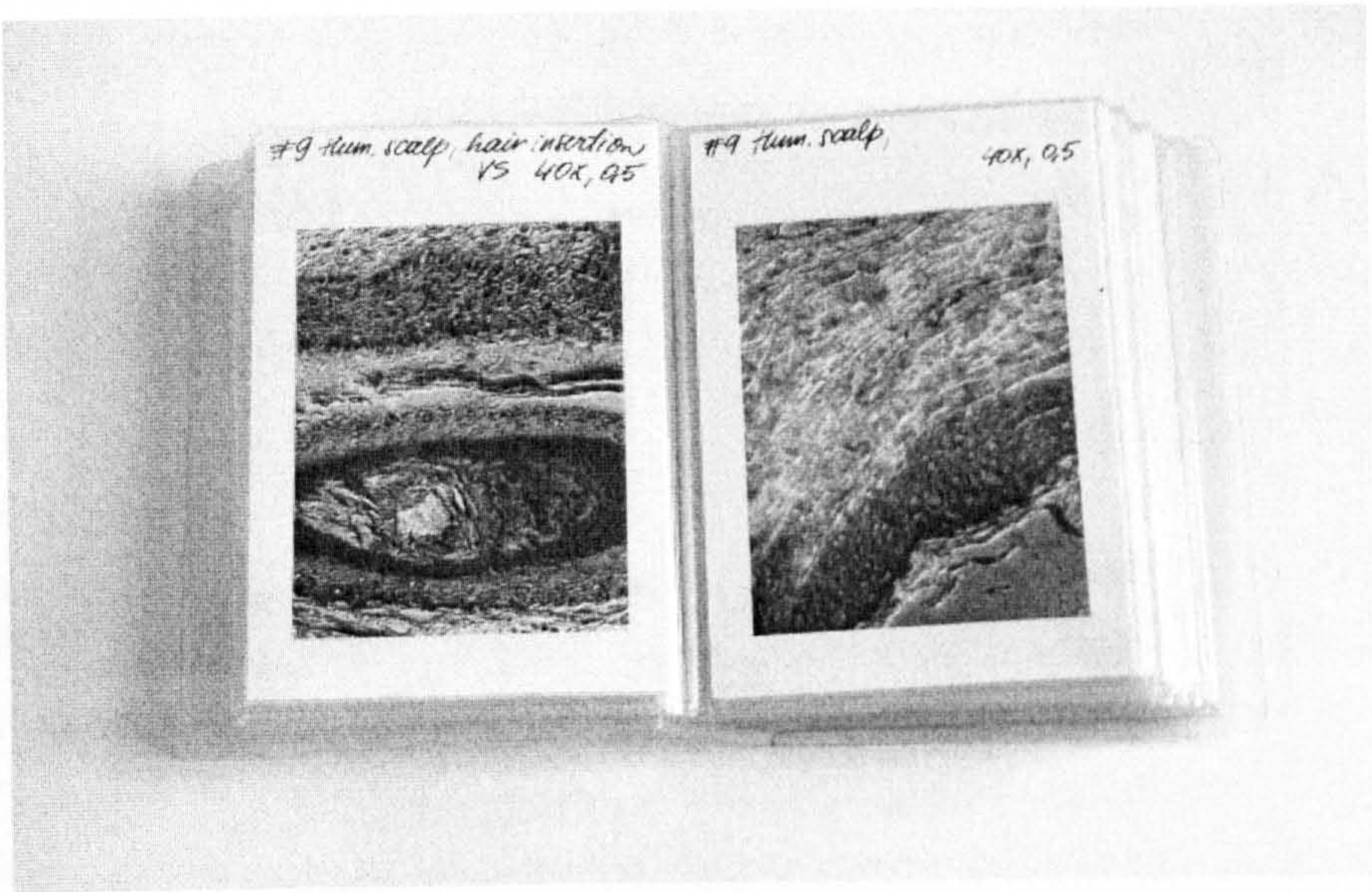


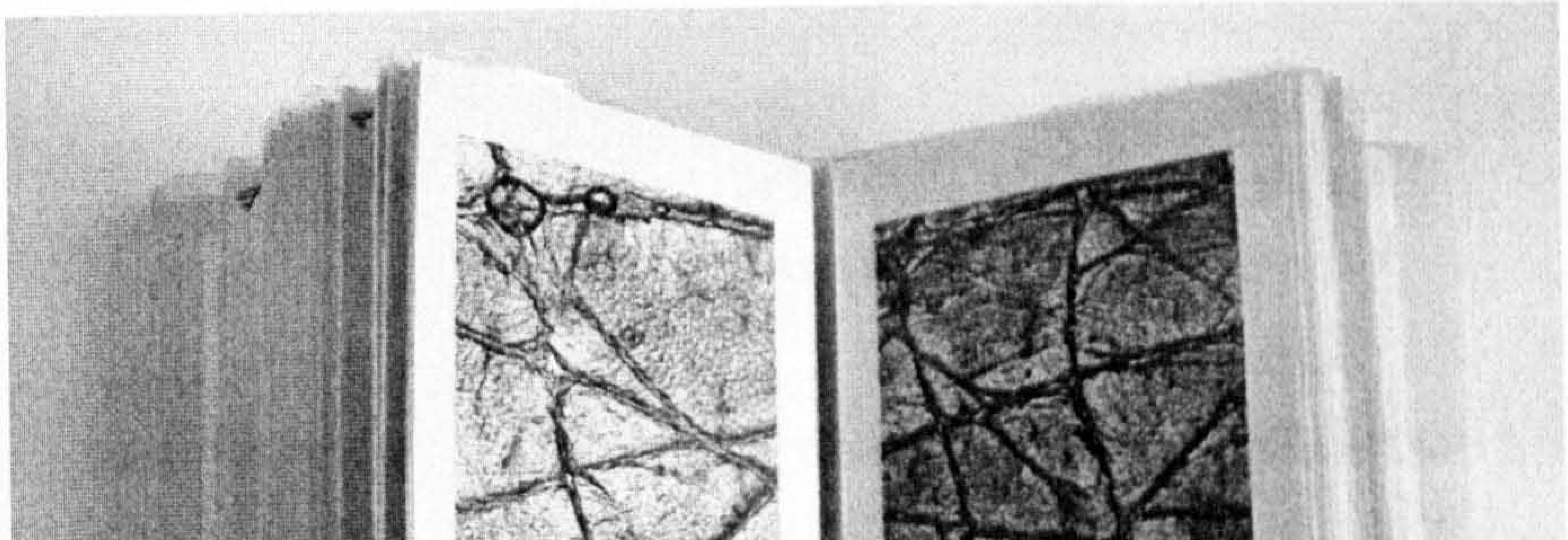




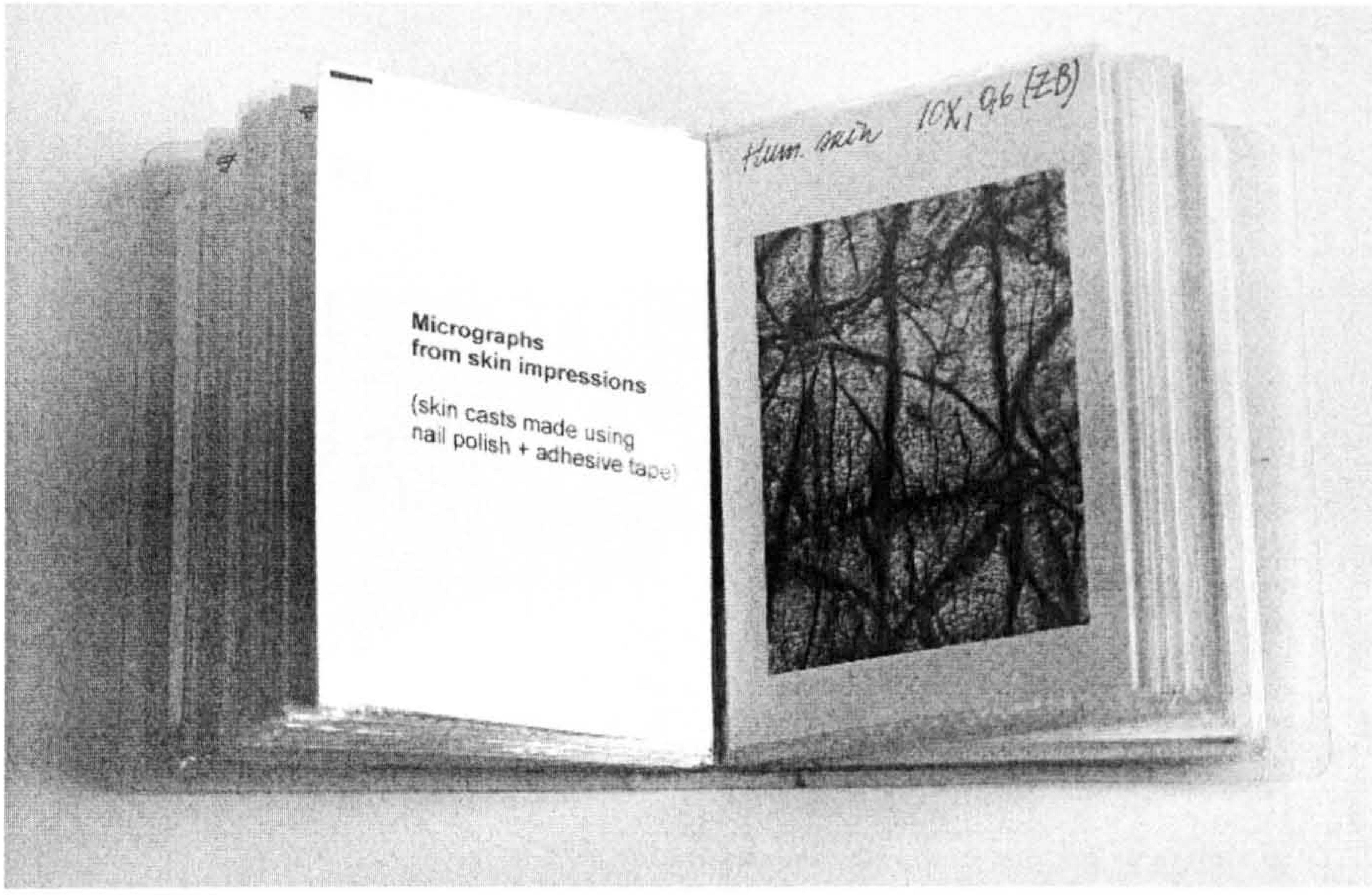
295 A. B. C. D. E. F. Log books
Selected images.

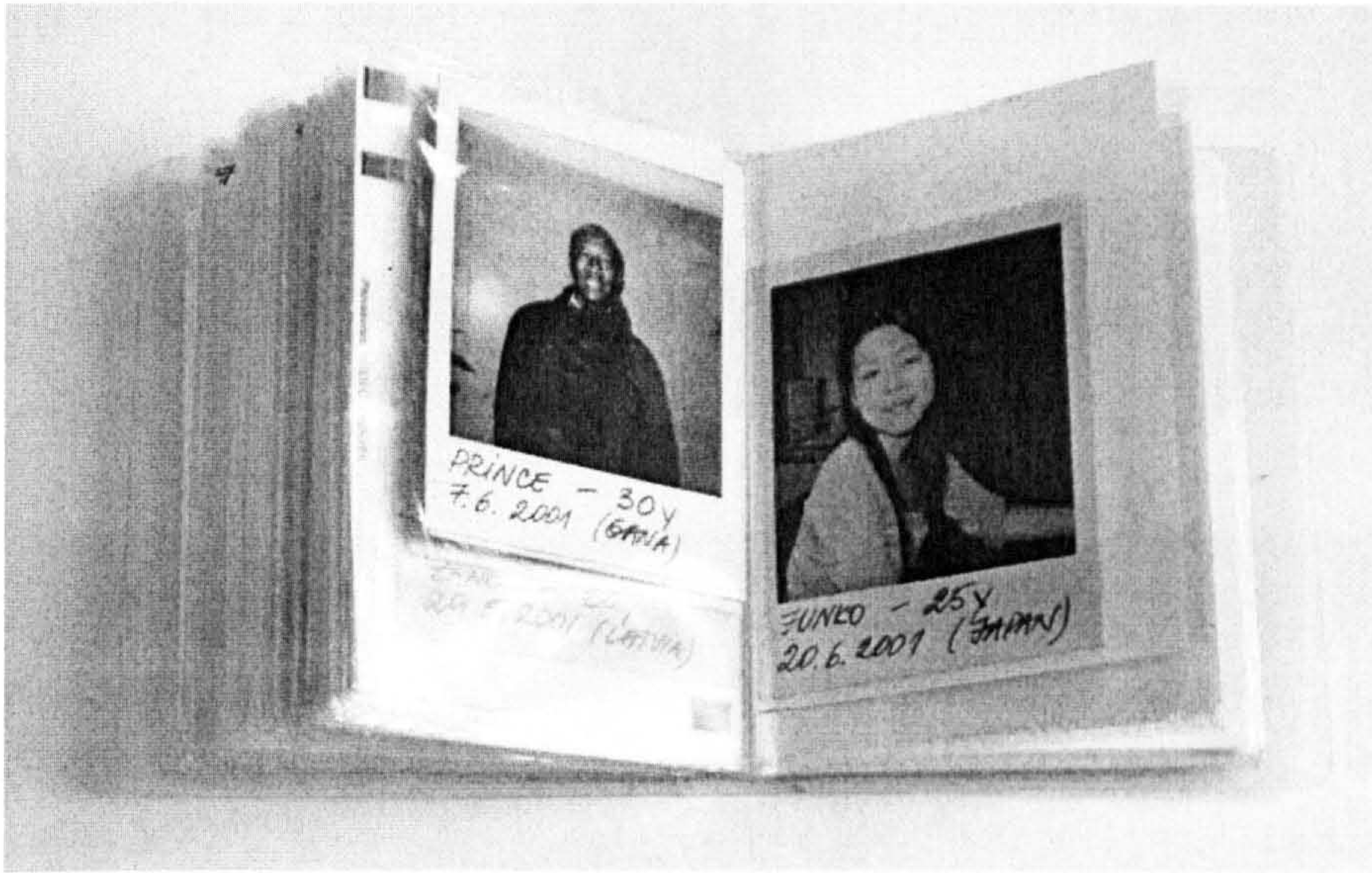


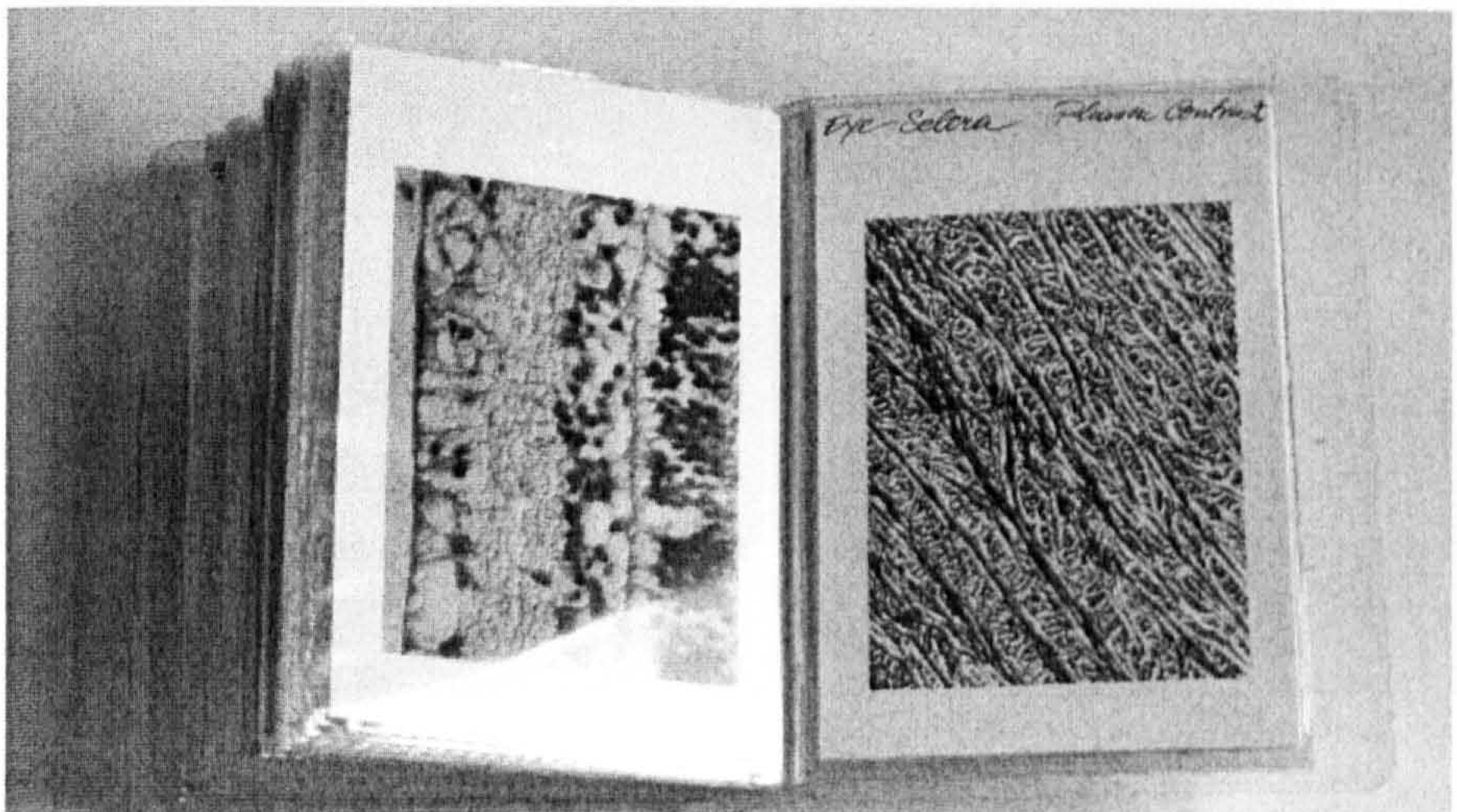




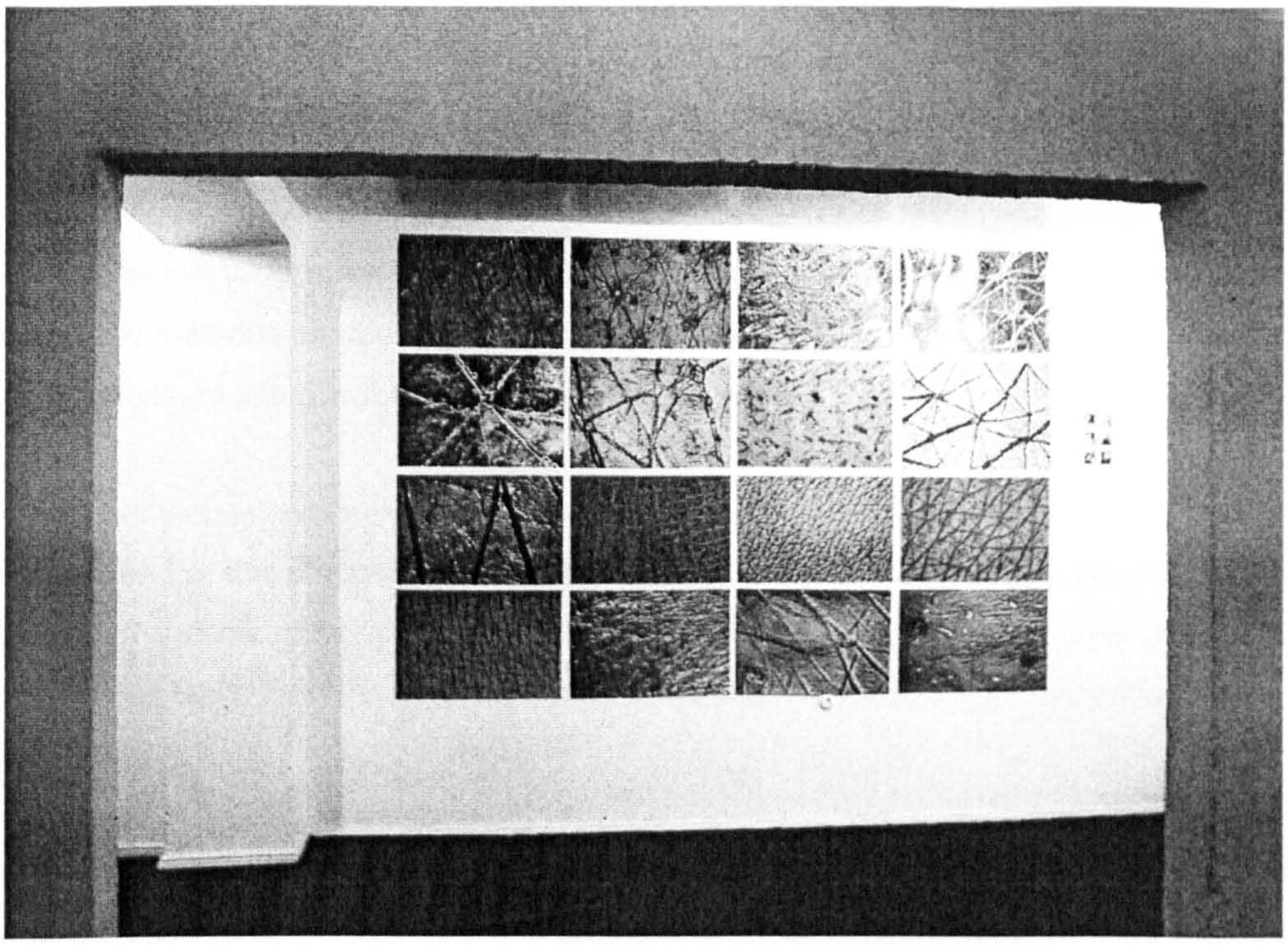
298 A, B, C Log books
Selected images







297 A, B, C. Log books.
Selected images



298, 299 SKIN SCHARTS
Exhibition view, gallery ACUD, Berlin, 2002.

APPENDIX C - PROJECT :: TOPOGRAPHY OF SKIN

SKIN CHARTS

Interrogation of the human body's physical data, using modern biological imaging systems, allows us to enter a new world: the microcosm of the human body. The use of scientific methods for charting and mapping the skin's physical data, its structures and functions, resulted in the photo series Skin Charts.

In this work various skin surfaces are investigated using people of different race, age and gender. For this purpose non-invasive research method was used in order to obtain skin surface impressions. So called negative replicas of the horny layer of epidermis were taken from the volunteers and photographed using a light microscope or optical lens.

Originally the negative replicas of the skin are transparent, containing no colour. By varying the conditions of light and changing lenses I was able to create the resulting images in their striking colour-ways influenced by my aesthetic considerations. I am interested in using high-tech magnifying facilities as a specific tool for making artistic decisions on how a particular biological specimen should be represented.

Work is accompanied by portrait photographs of the donors - people from whom the Skin Charts have originated, including a short description of their age, nationality and the locations from where skin casts were taken.

Series Skin Charts is by courtesy of the Museum of Modern Art in Tallinn, Estonia.

TOPOGRAPHY OF SKIN

The microscope is a tool for creating impressive illusions. It has relatively little to do with so called 'objective reality'. It magnifies structures within the object but it does not necessarily show the 'truth'.

The way that people look at the world and what tools they use for their navigation is culturally determined. Topography of Skin is a comment on Western medicine and the biomedical practice of mapping the human body as a foreign territory. This approach automatically introduces the idea of body as machine by separating the soul and the body.

For my work I have used a negative skin cast taken from my own epidermis. The biological slide was investigated using a light microscope, magnified, photographed and digitally rendered to a black and white image, which was then magnified again (23 times) until no pattern of the skin surface structure is visible. The sequential intermediate images taken during the process of magnification demonstrate the fading path towards the final image, which is a completely empty sheet of white paper.

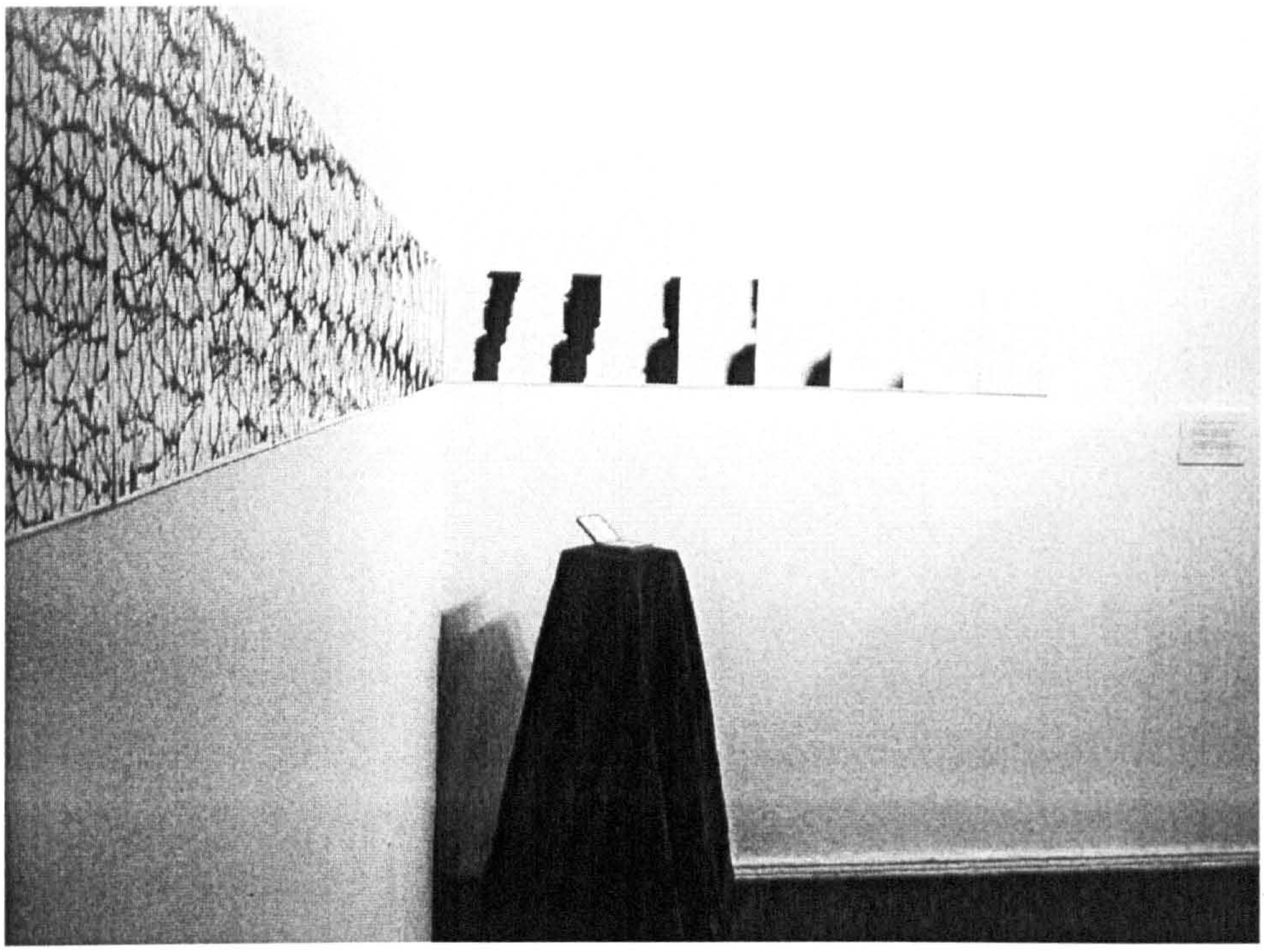
Topography of Skin is also a poetic work about privacy, intimacy and proximity.

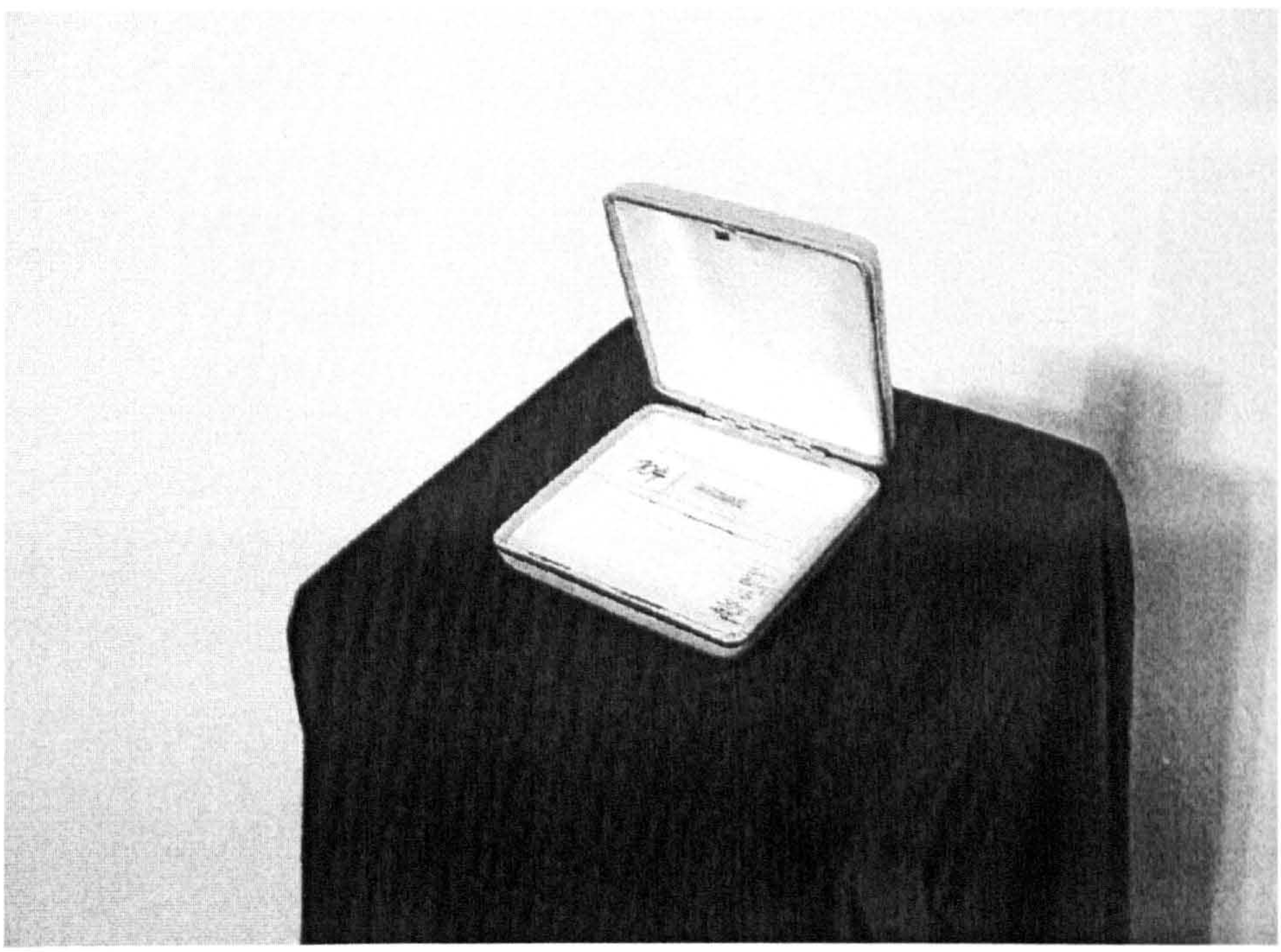
TOUCH

In biological terms, our body has become a kind of replaceable 'Homo-kit' - it is possible to replace the non-functioning liver, do artificial skin implantation or to influence the desirable physical and intellectual properties of the unborn child.

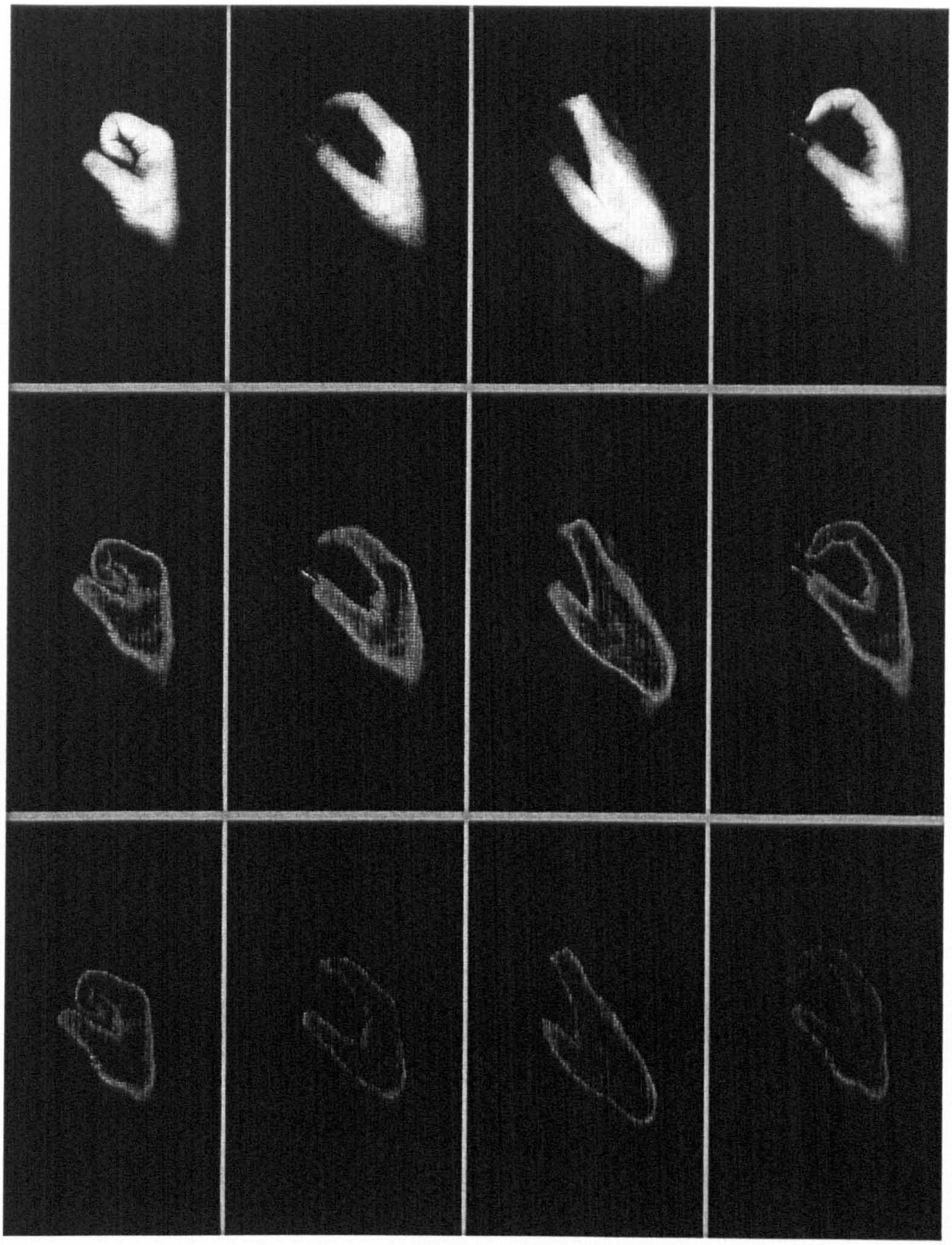
Nevertheless, in the collective consciousness the skin remains the site where the 'I' finds its home. It is the border at which subjects can meet. In 20th century philosophy and art, the skin has often been used as a metaphor for isolation, distance between people and the strangeness of the 'other'. Historically, the cultural preoccupation with skin has become increasingly visual.

Skin is our interface with the outer world. The work series Touch investigates our contact points with the environment. In this project the movements of the hand are sequenced, attempting to catch the trajectory of the movement.

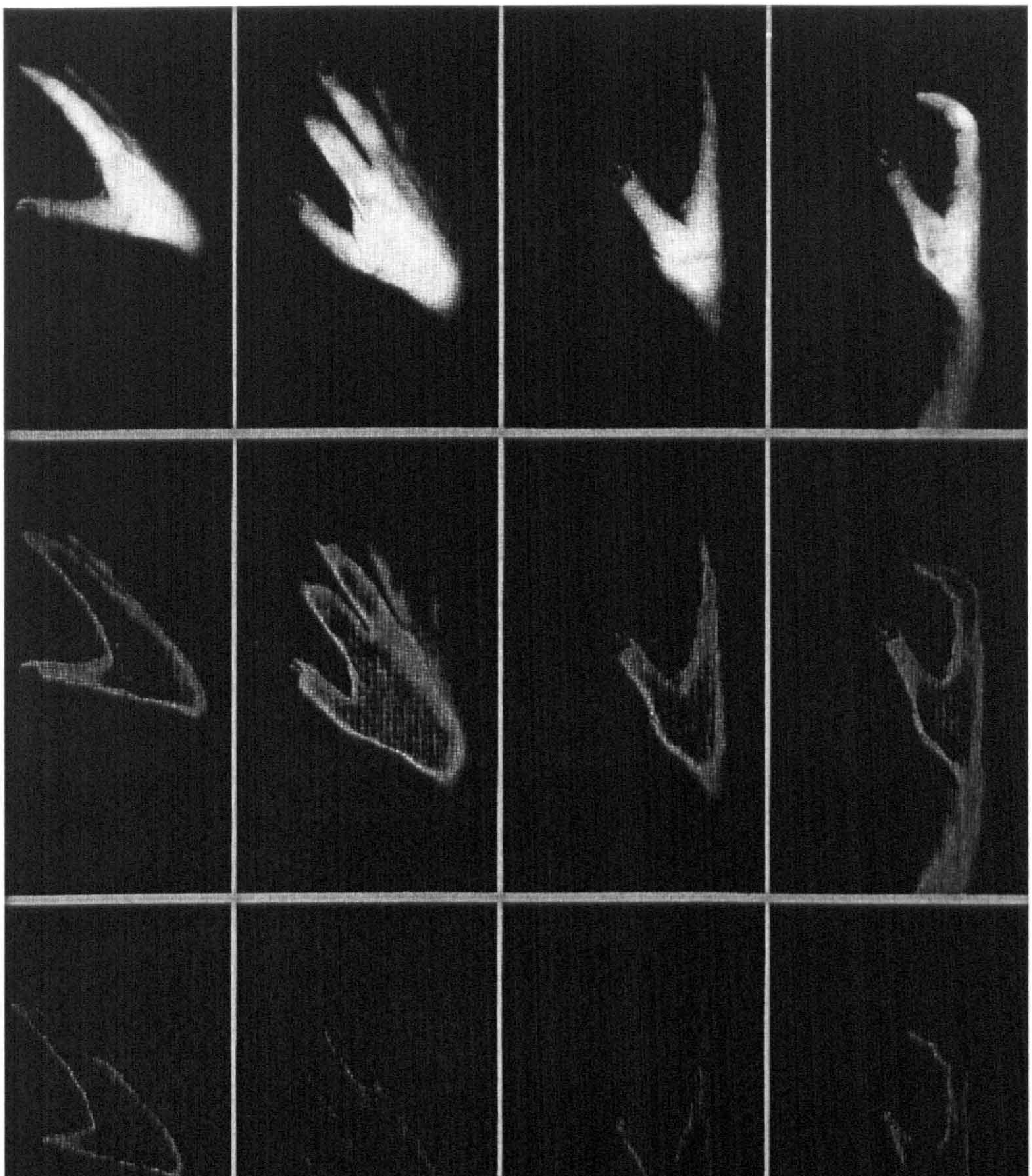




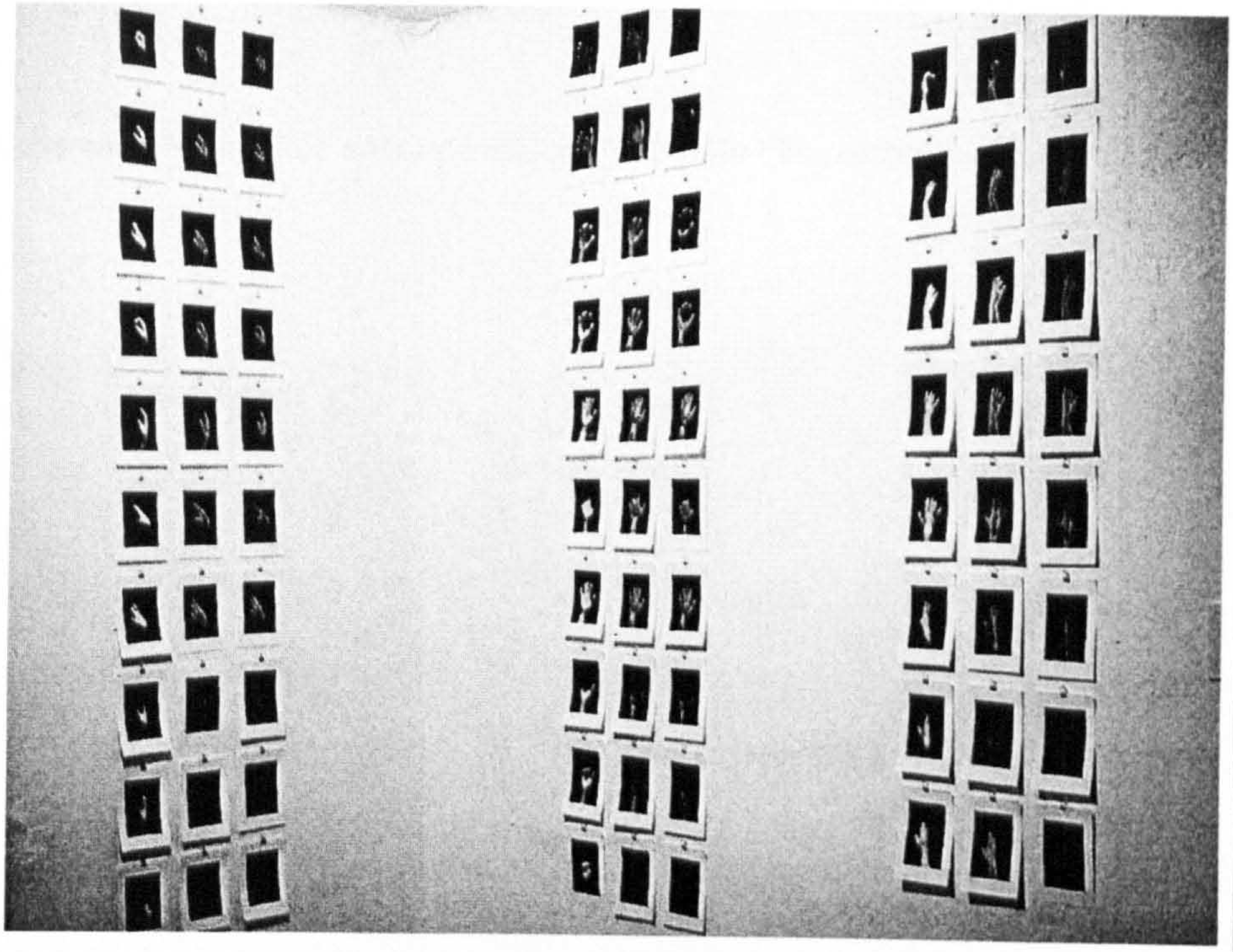
300, 301. TOPOGRAPHY OF SKIN.
Exhibition view, gallery ACUD, Berlin, 2002



302 A TOUCH, 2002.



302 B TOUCH, 2002.



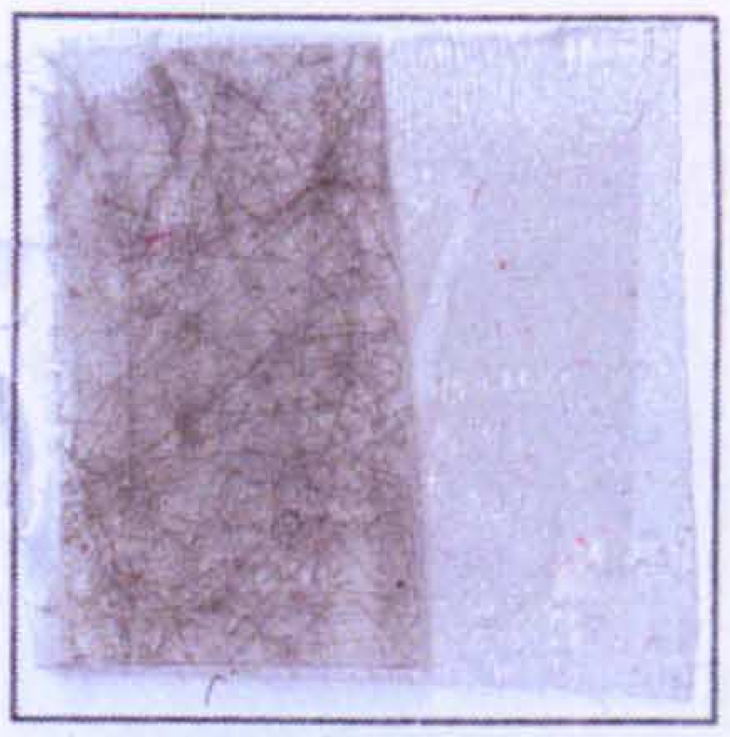
303 TOUCH.
Exhibition view, gallery ACUD, Berlin, 2002.

APPENDIX D

TEXTILE FILES :: INDEX CHART

Textile samples are in a separate folder. For Textile File please contact author.

Sample No 1

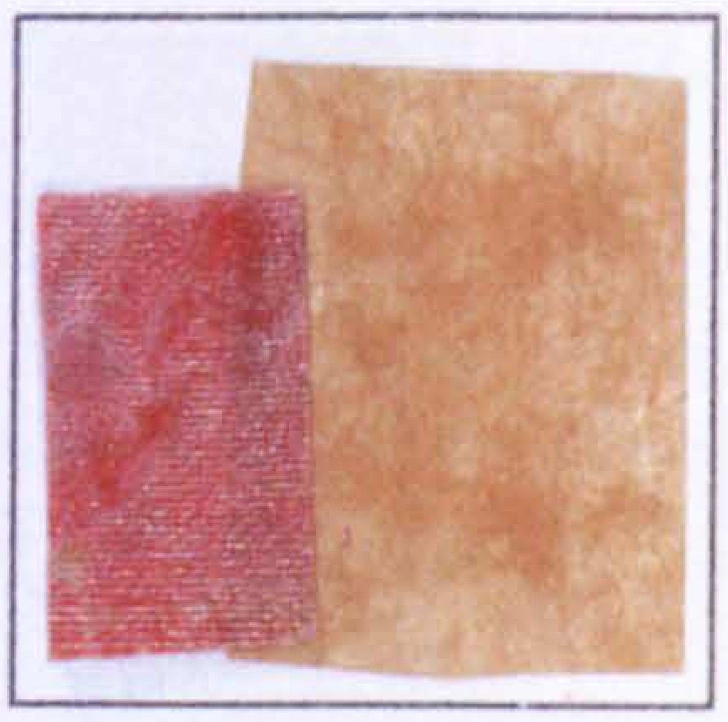


Sample No 2

Sample No 3

Sample No 4

Sample No 5



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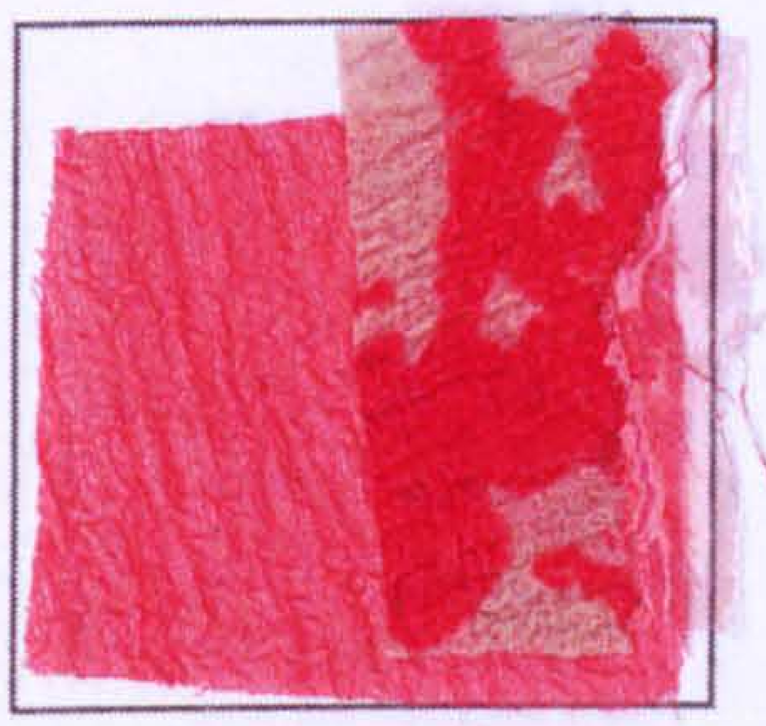

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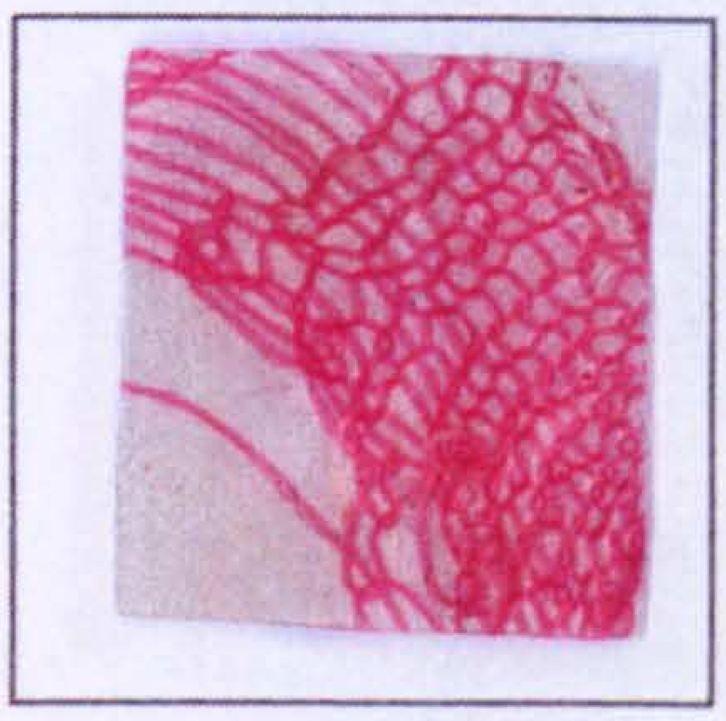

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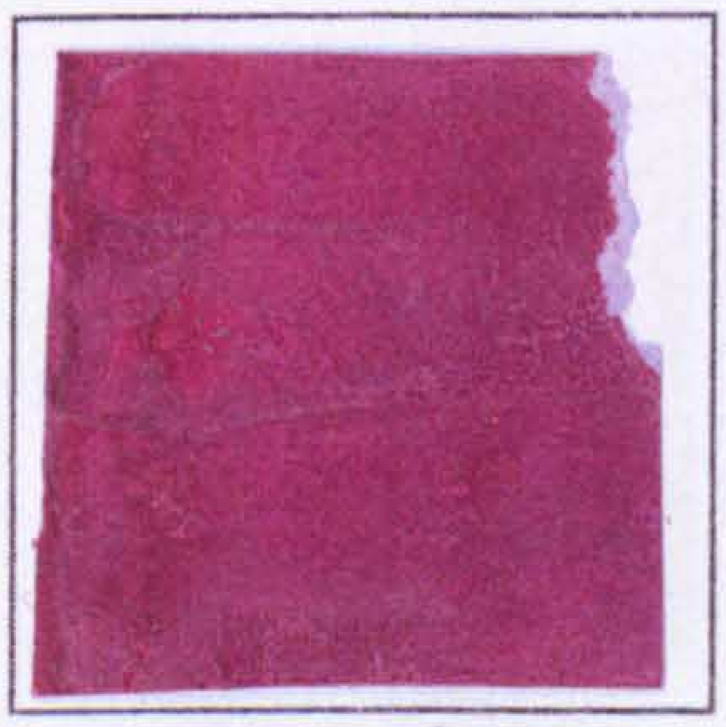
Sample No 9



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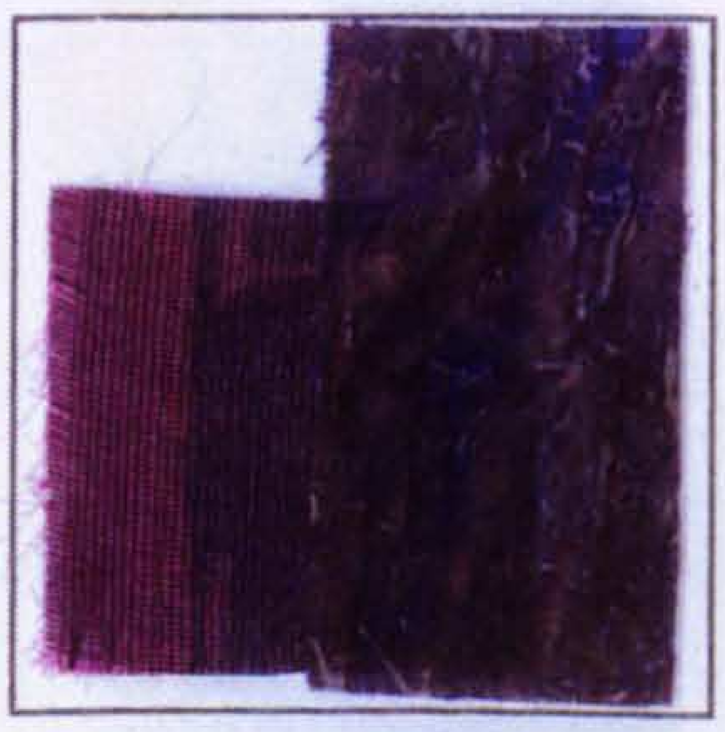

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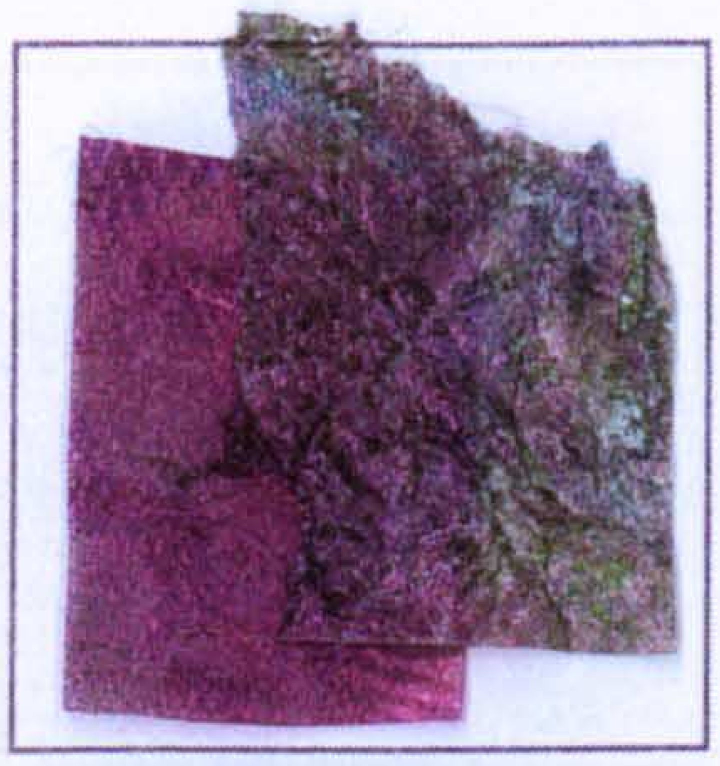

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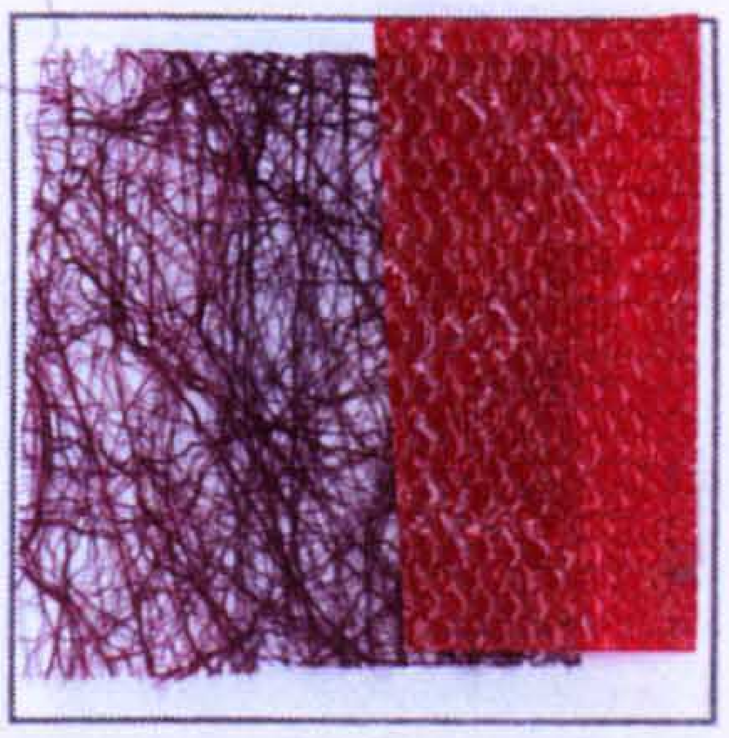

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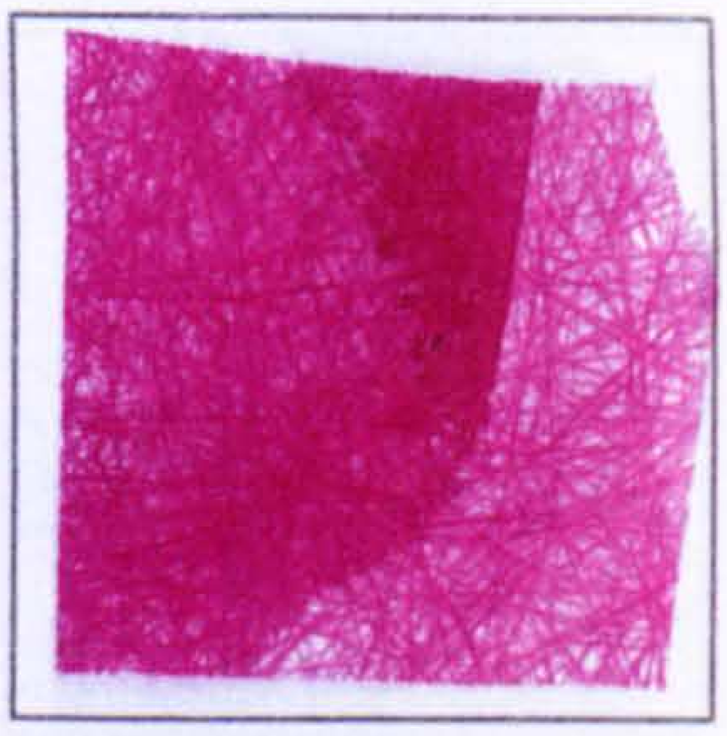

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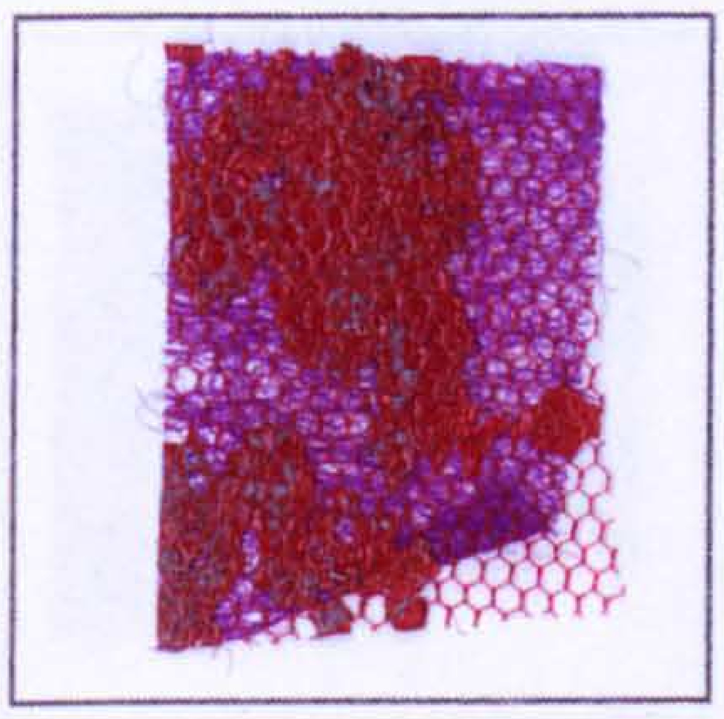

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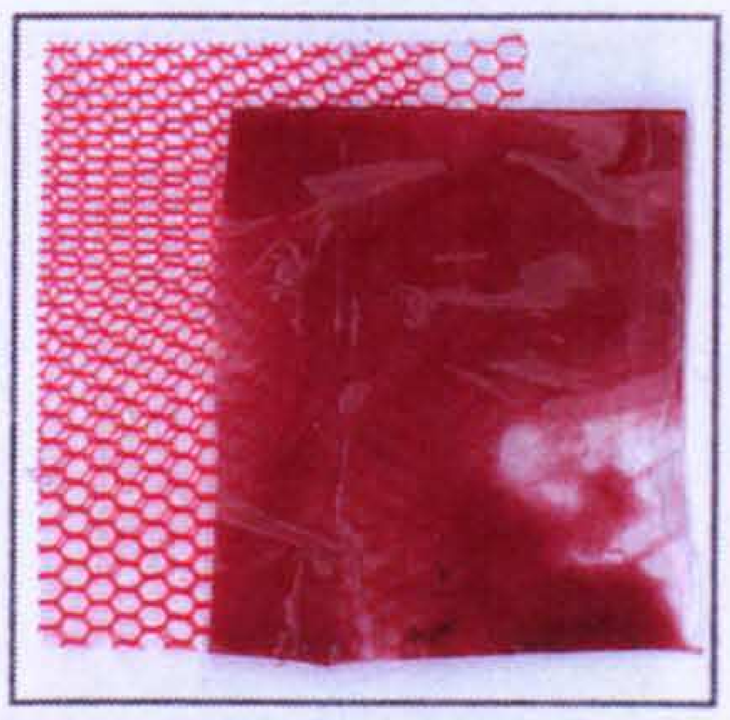

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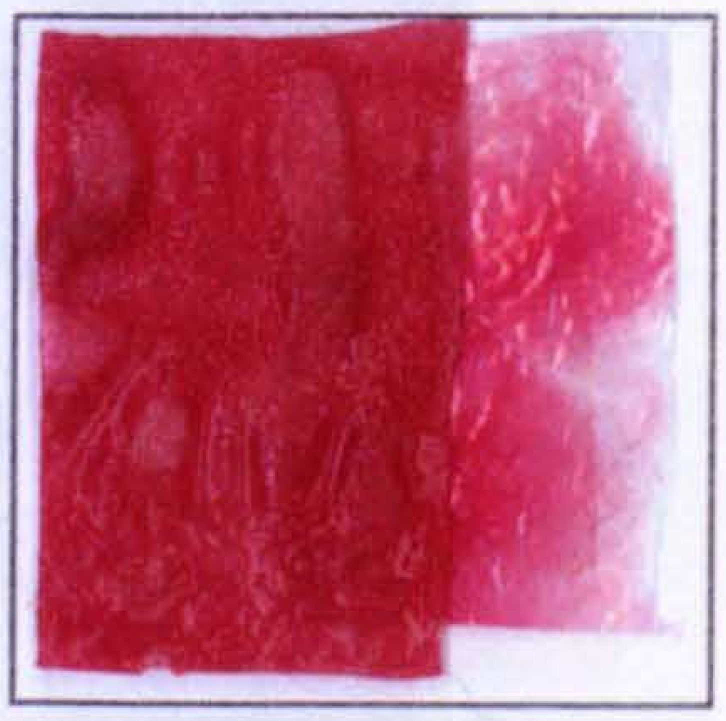

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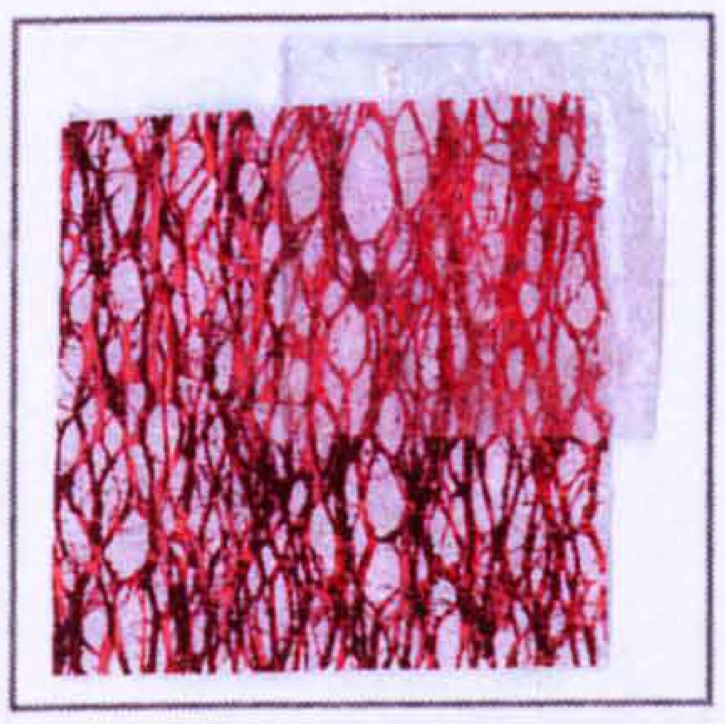

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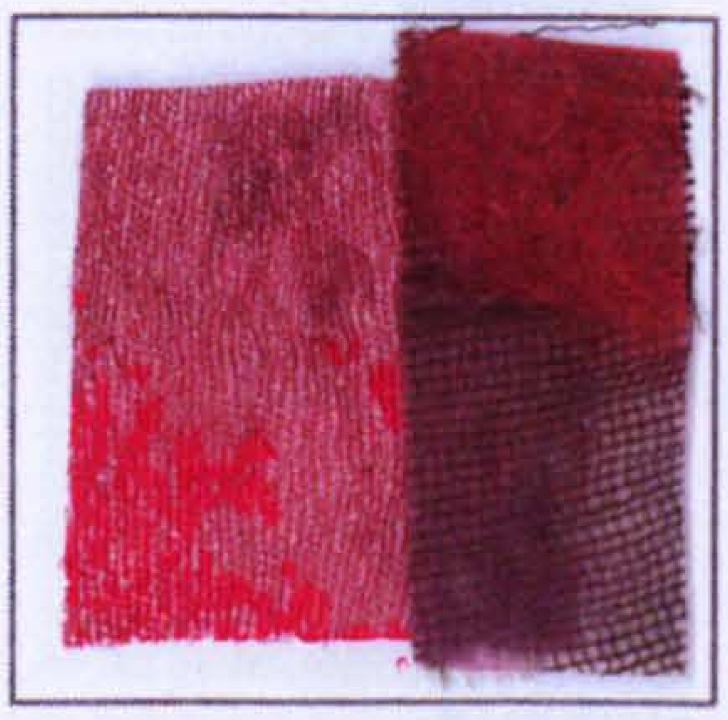

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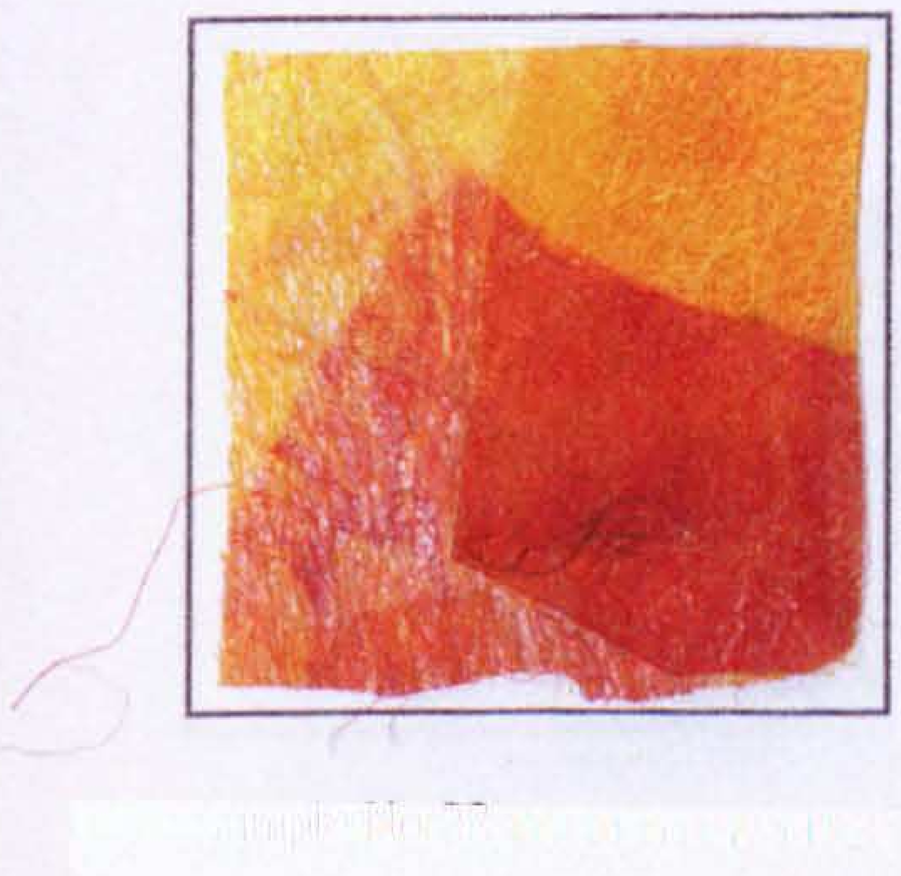

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Sample No 23

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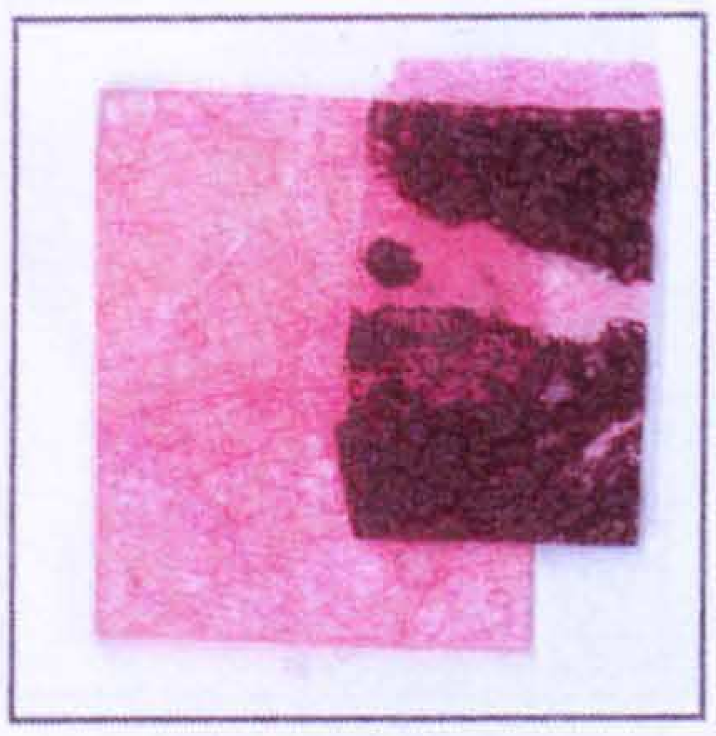

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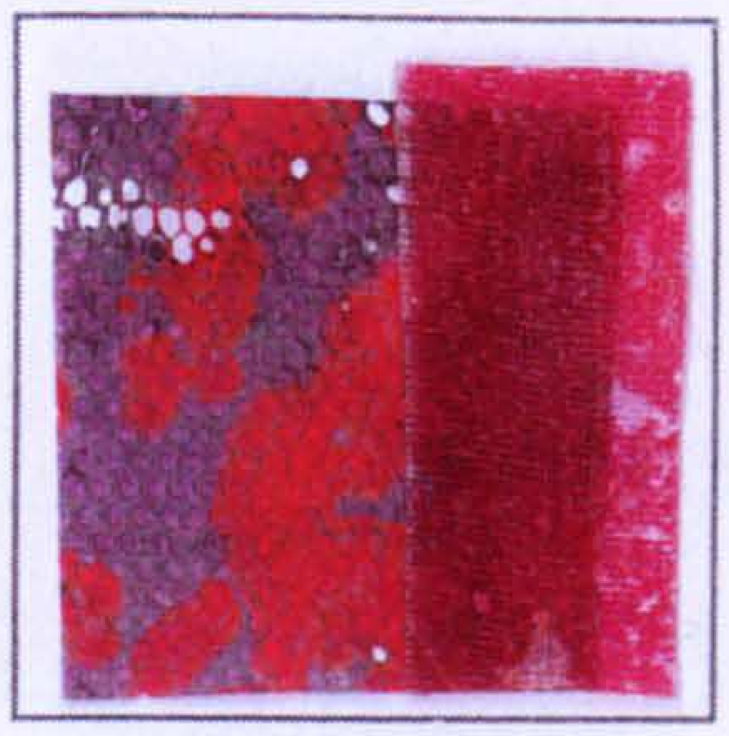

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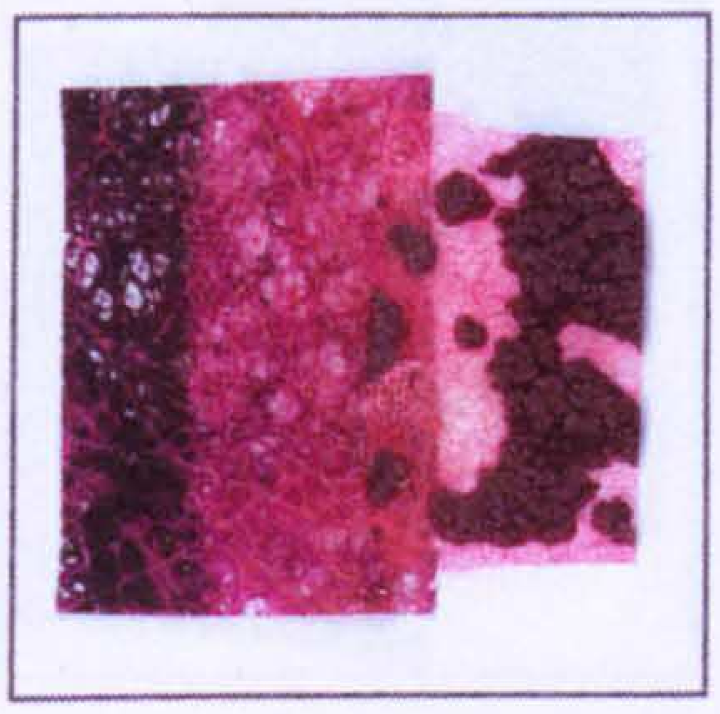

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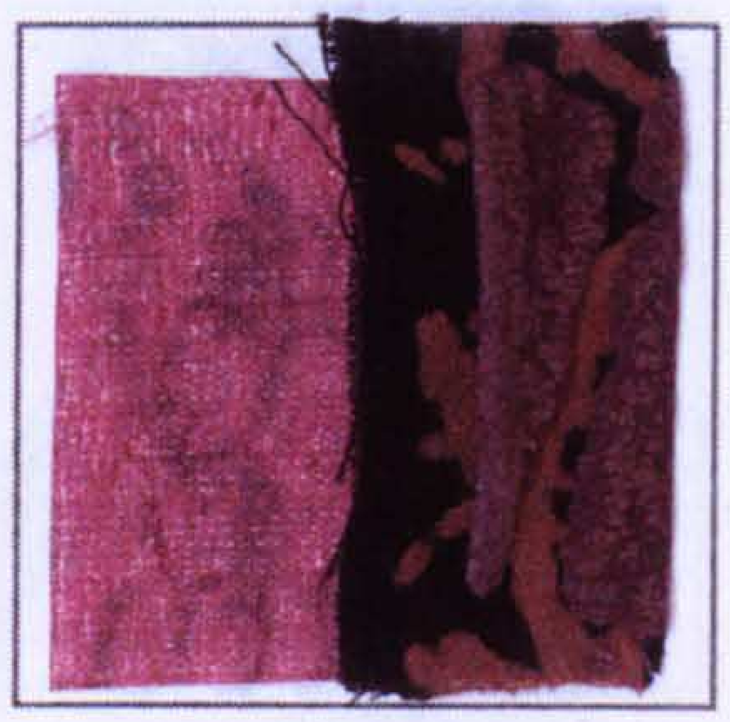

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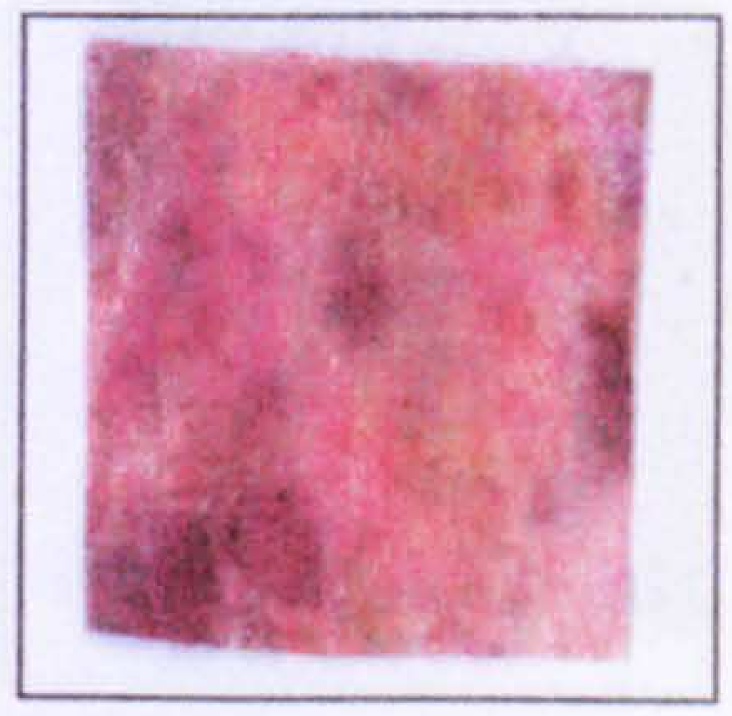

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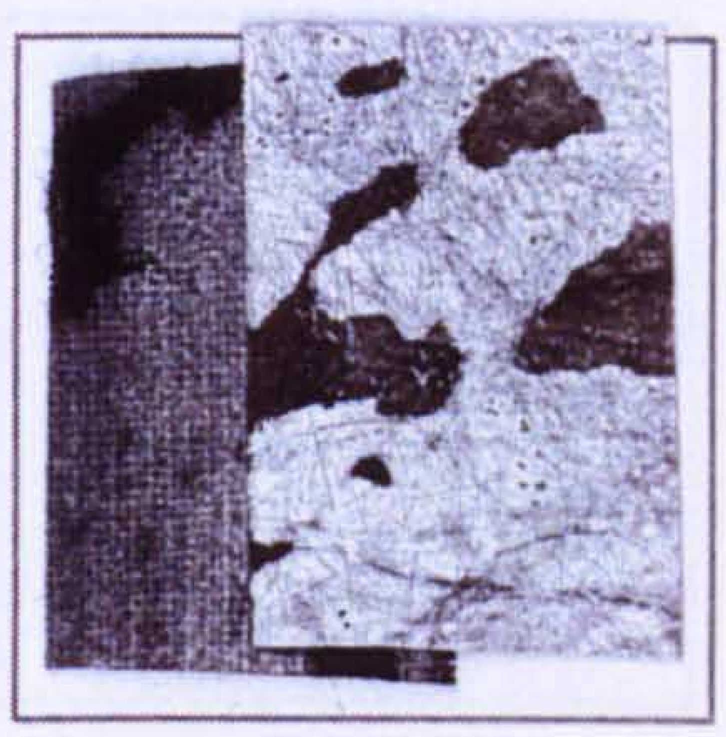

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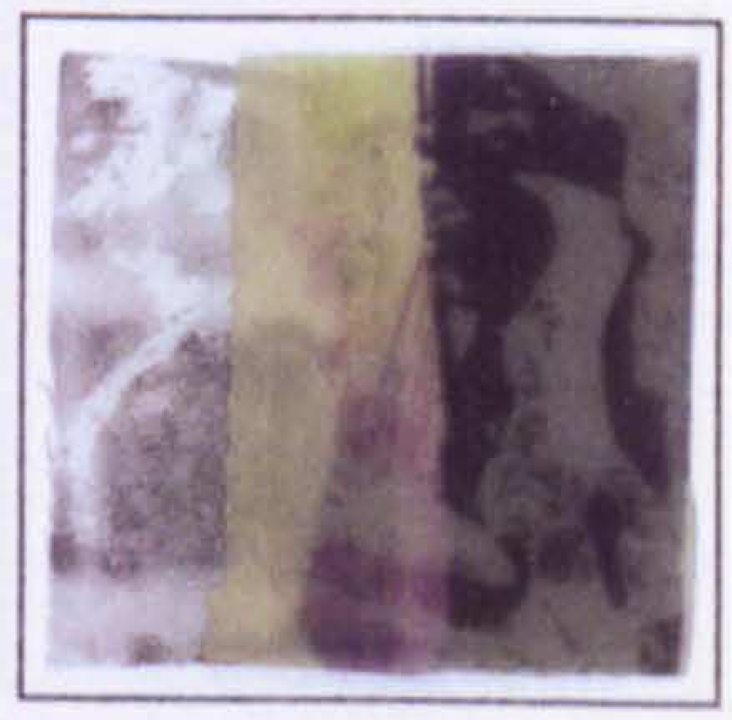

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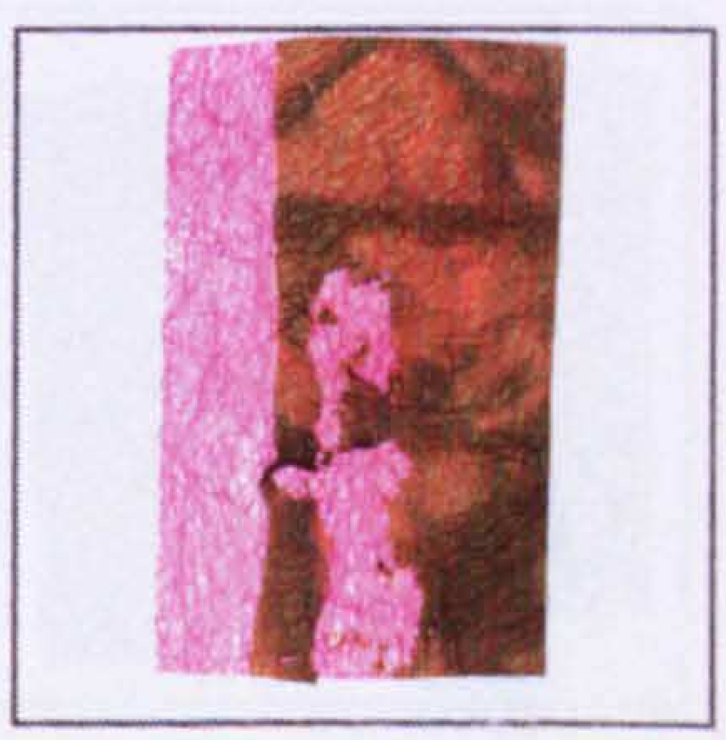

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Sample No 37

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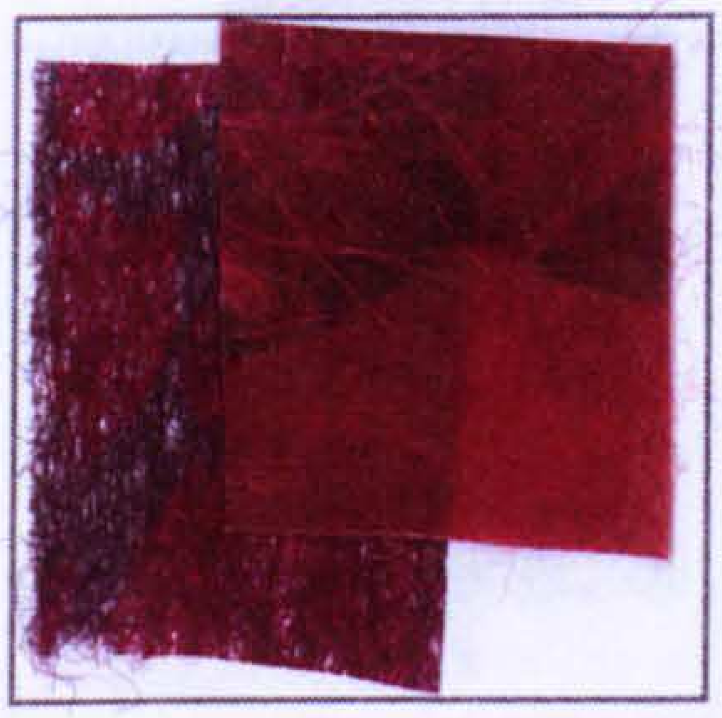

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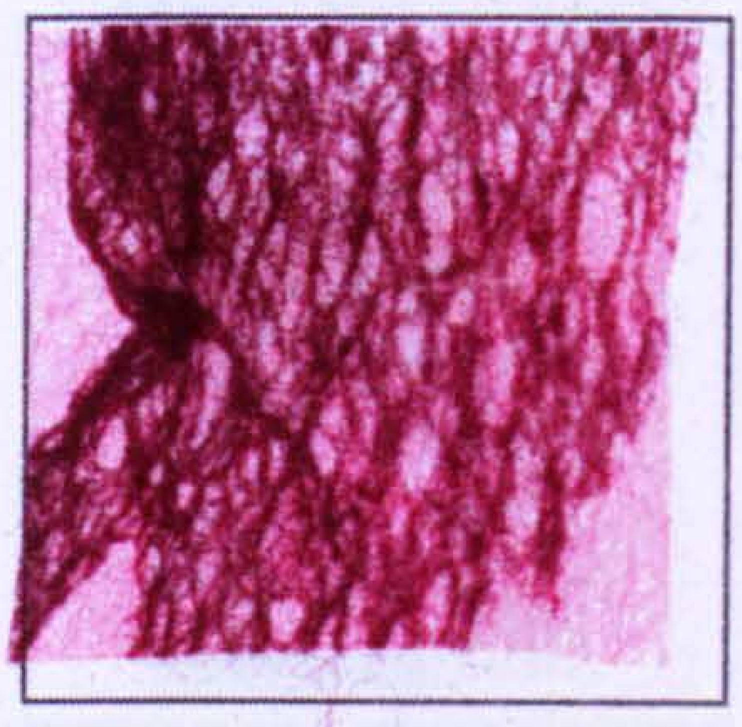

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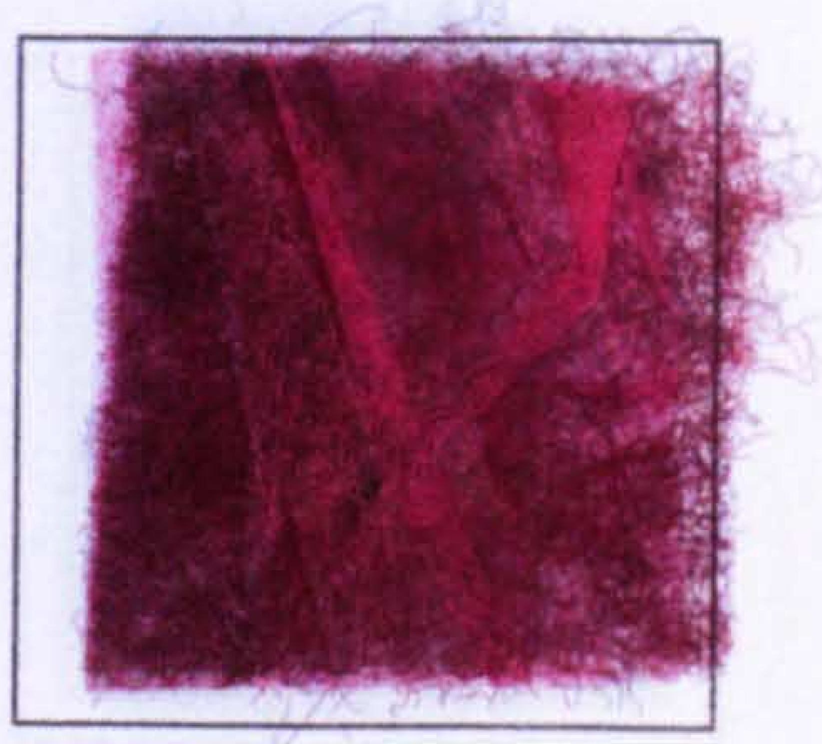

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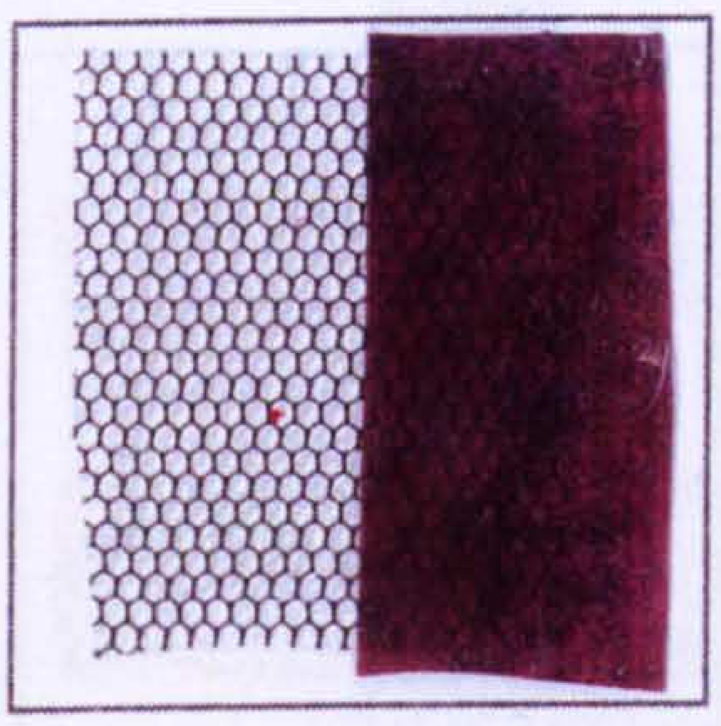

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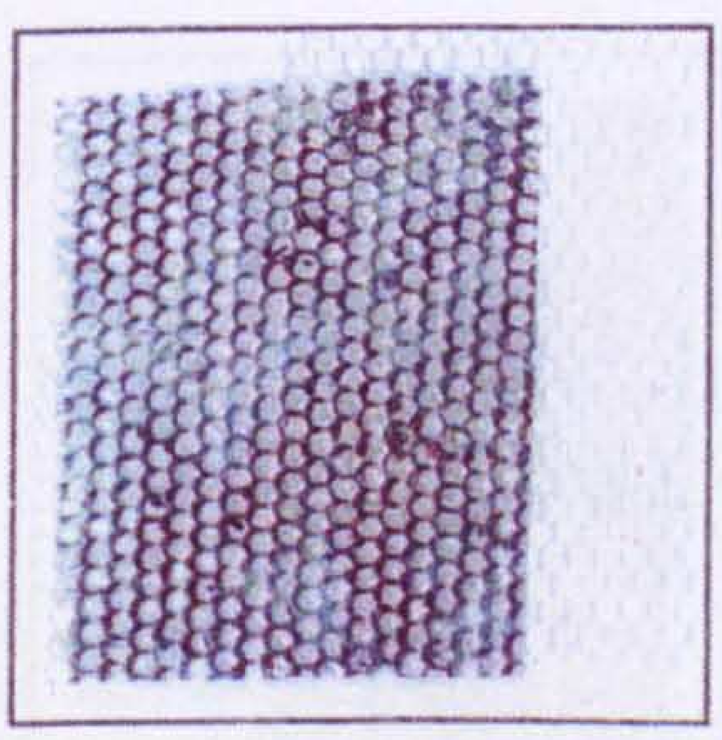
Sample No 44

Sample No 45



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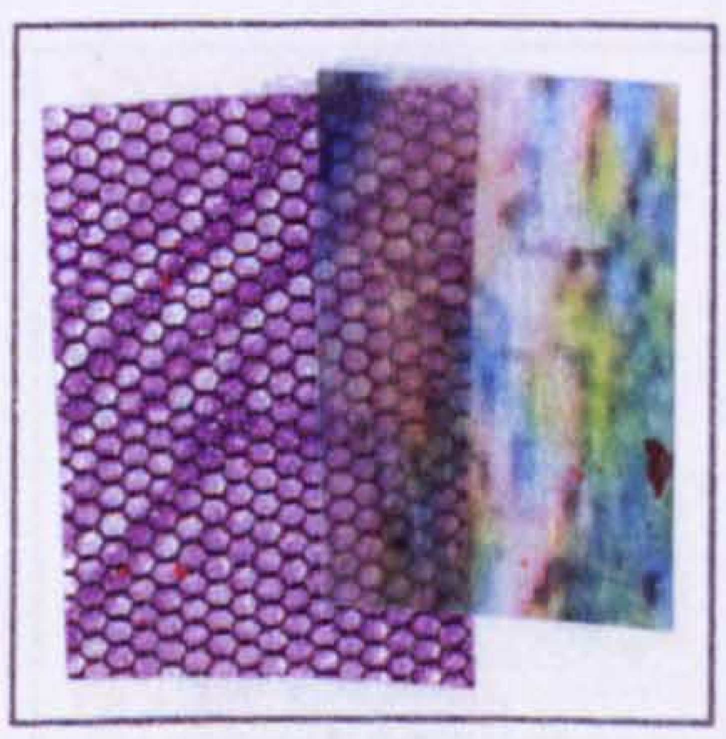

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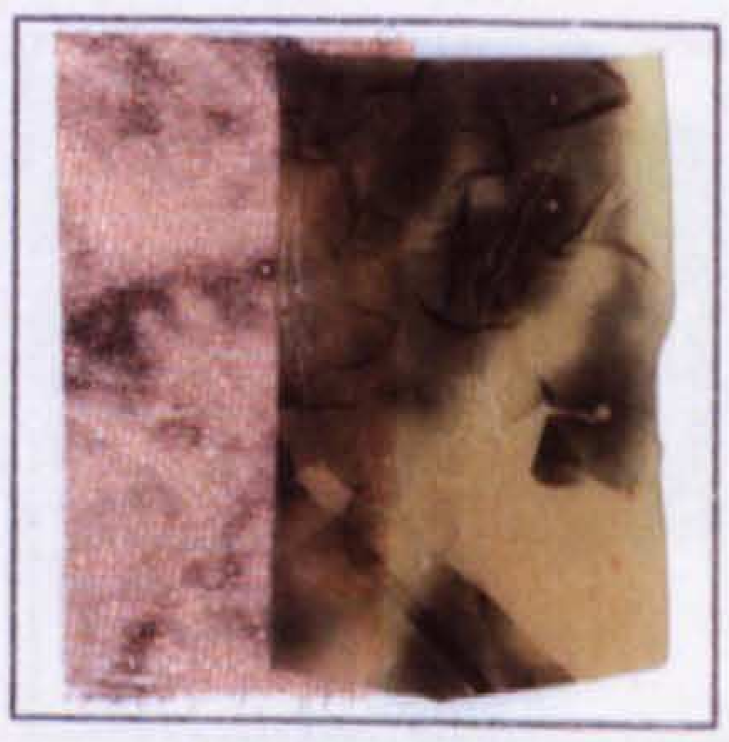

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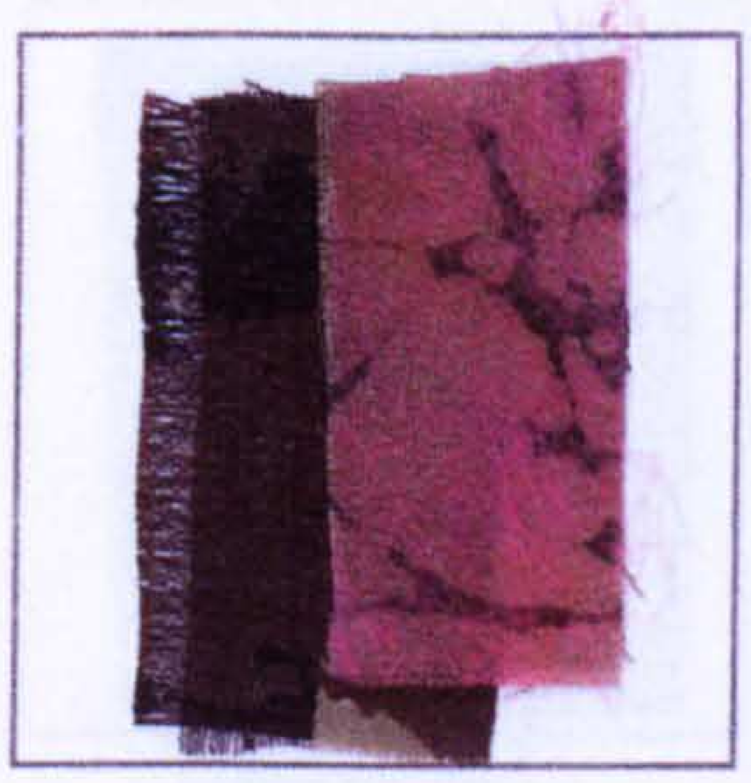

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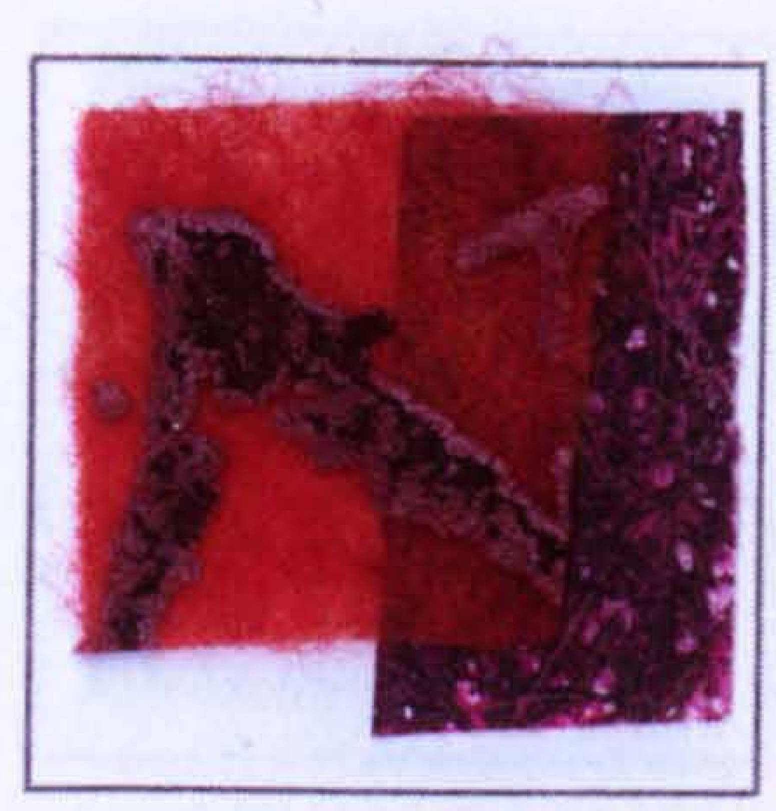

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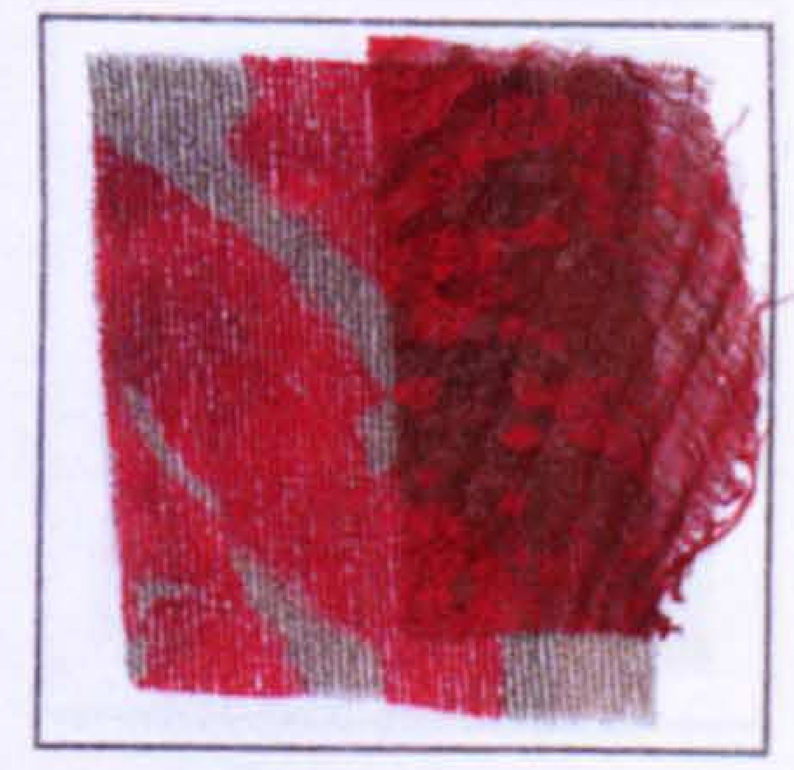

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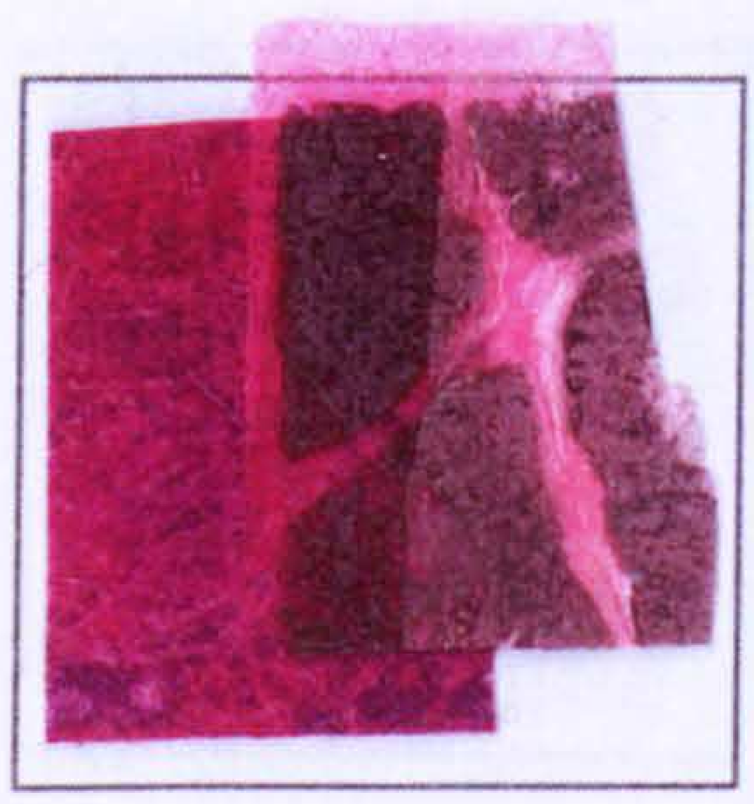

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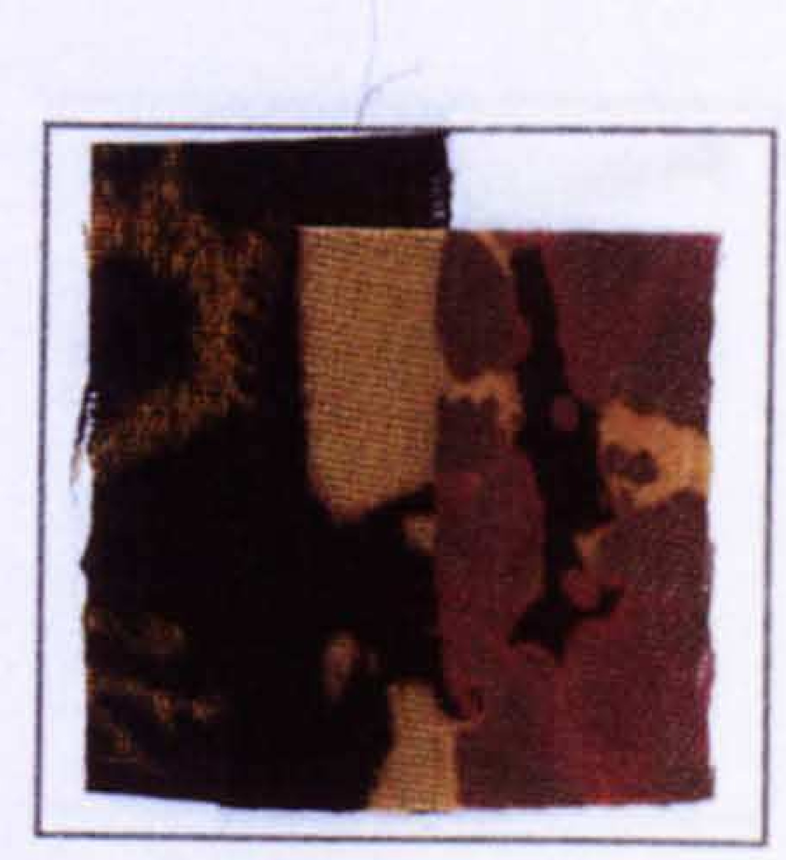

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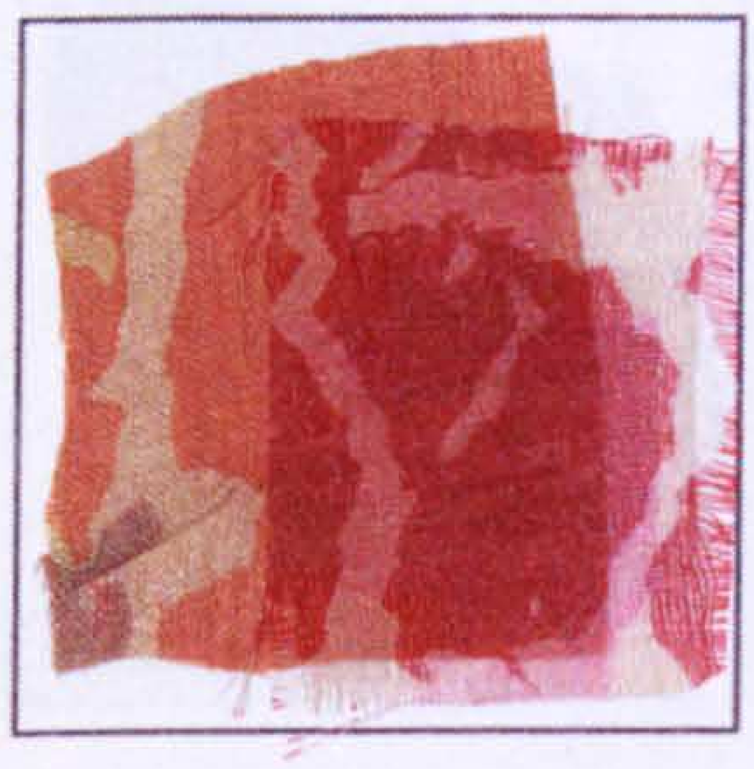

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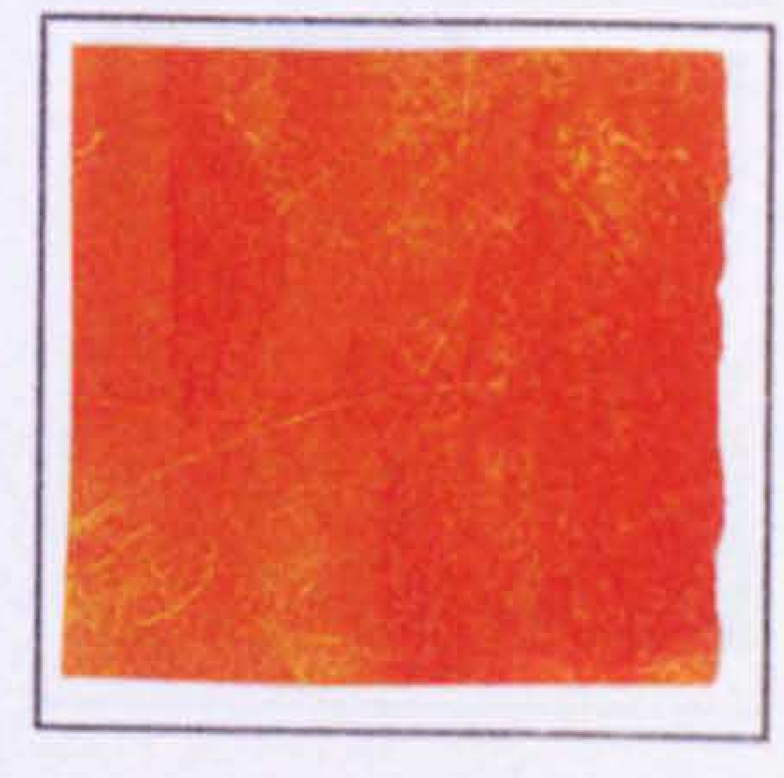
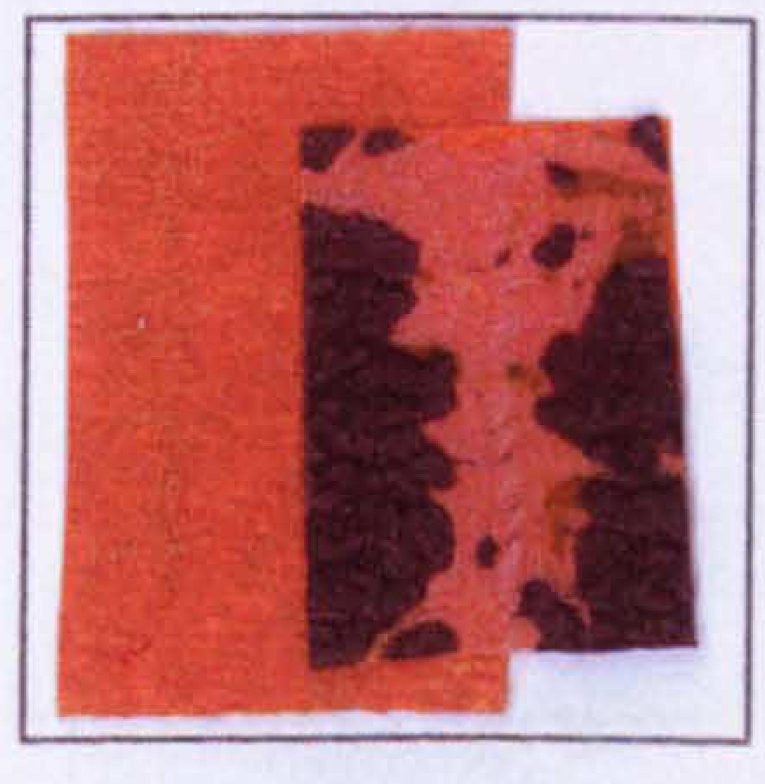


Sample No 57

Sample No 58



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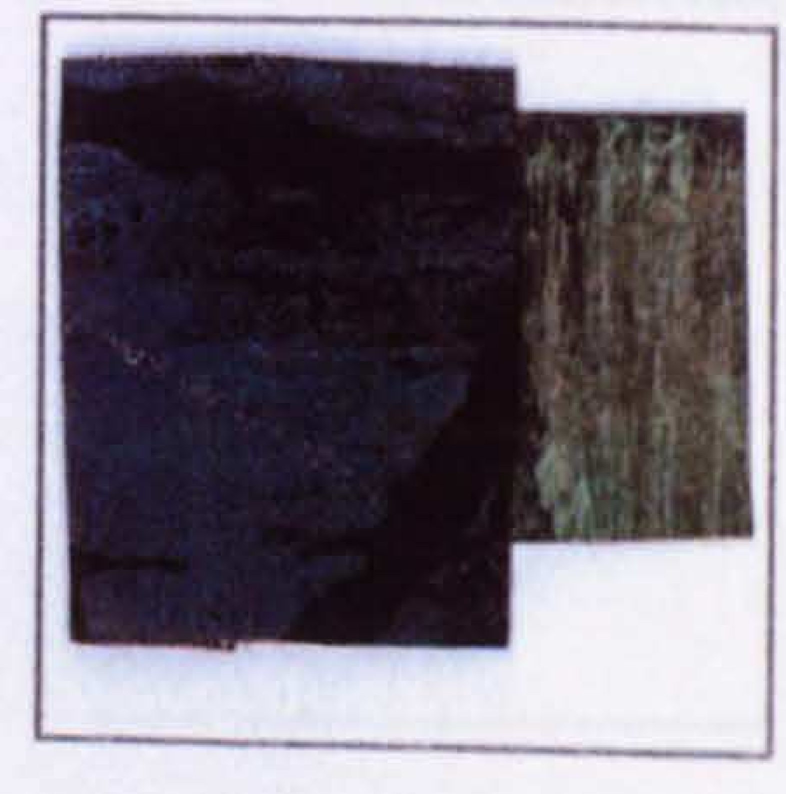

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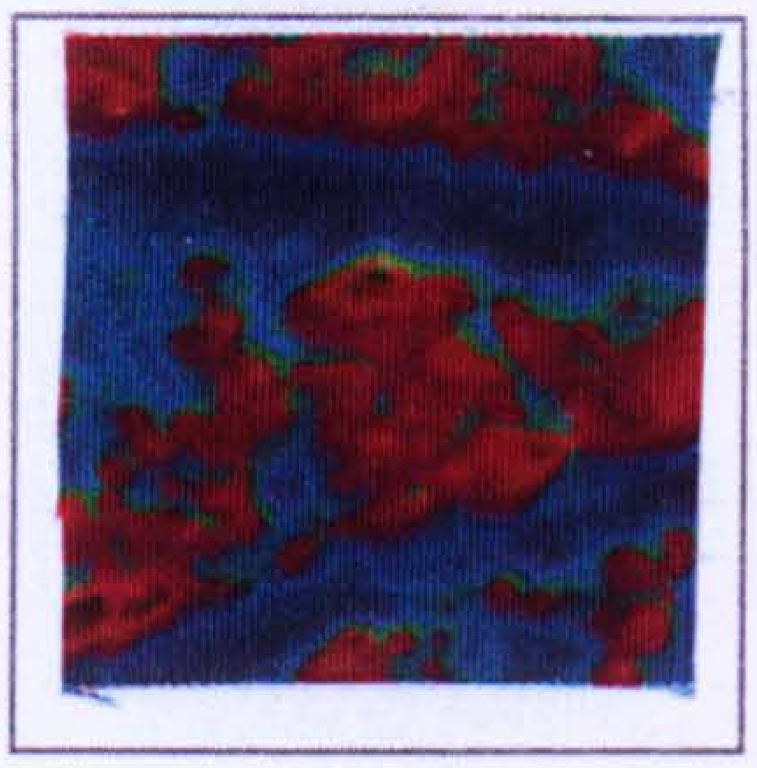
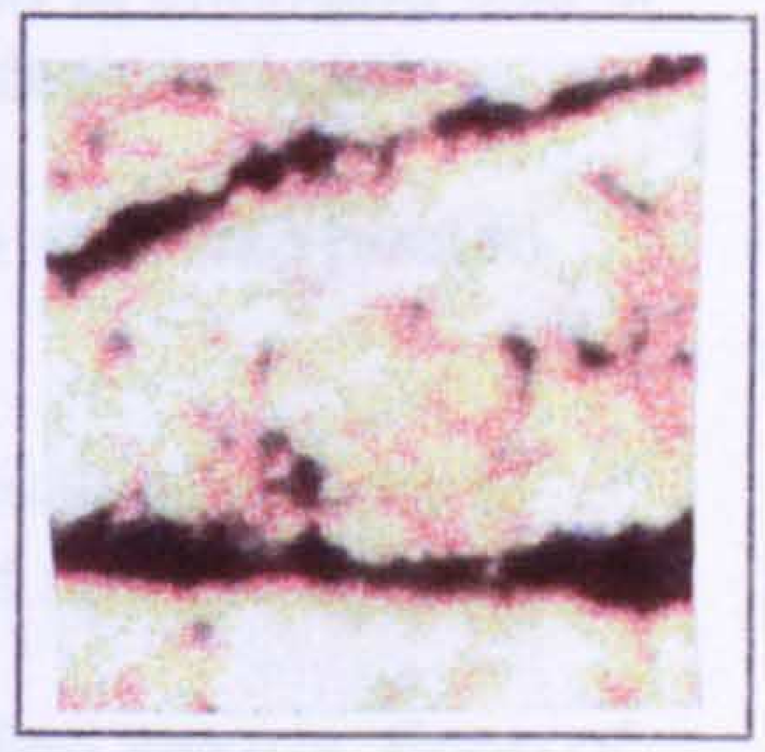


Sample No 62

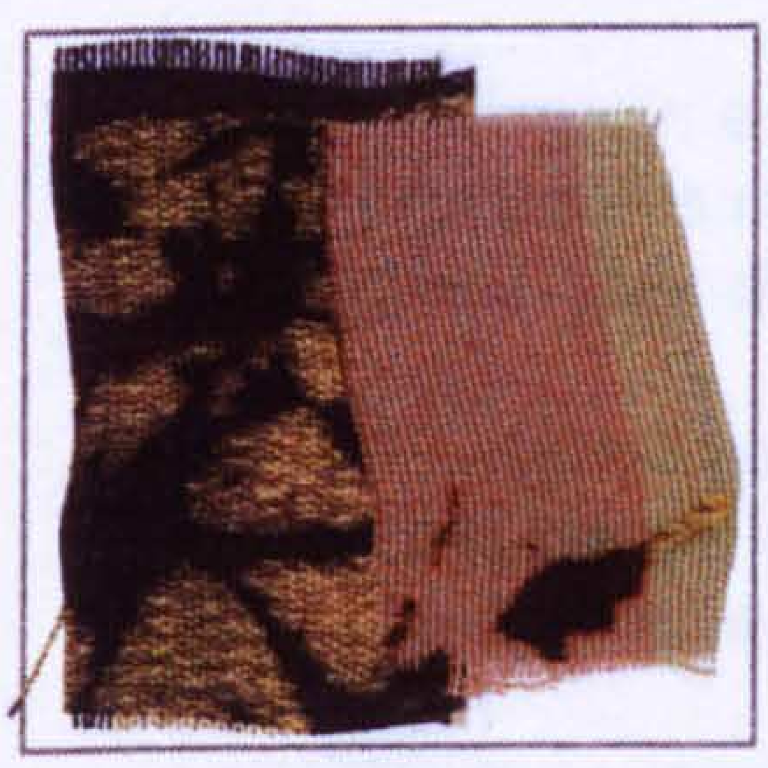
Sample No 63

Sample No 64

Sample No 65



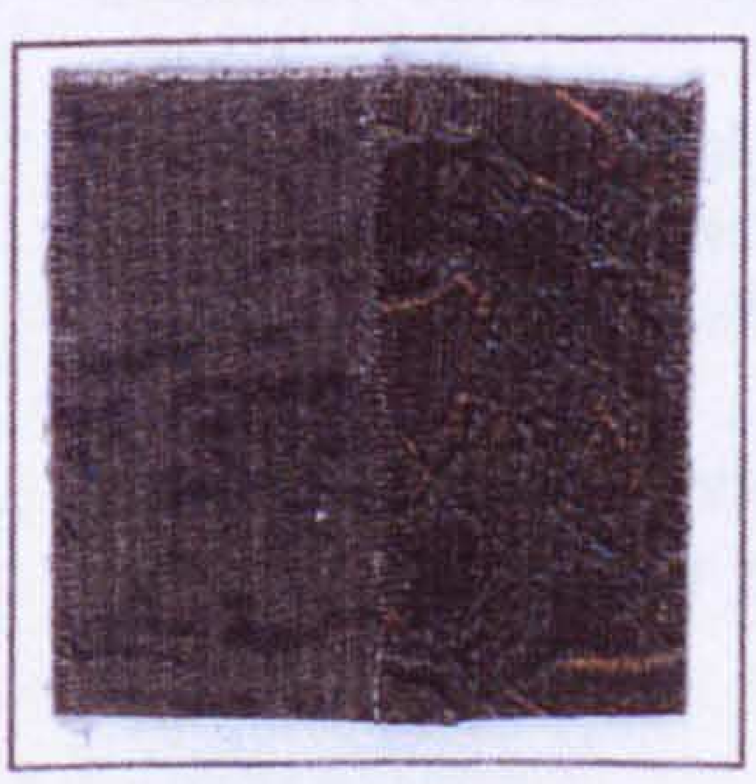
Sample No 66



Sample No 67

Sample No 68

Sample No 69



Sample No 70

Sample No 71

Sample No 72

GLOSSARY

BIOMEDICAL TERMS

biomedical engineering: see tissue engineering.

biomimetics: is a modern word, first used at a workshop in 1991 organised by the US Air Force Office of Scientific Research. Its purpose was to look at what biology had to offer in terms of design and processing of materials. This specific transfer of technology is variously called: bionics, biomimetics or biognosis.

body modification: a generic tern for variety of techniques aimed at changing one or more parts of the body from the natural state into a consciously designed state.

branding: a form of scarification usually achieved by burning the skin with heated metal.

capillary: a tiny blood vessel, the wall of which is only one cell thick. Networks of capillaries function to exchange gases and liquids between blood and the tissues.

cicatrization: decorating the skin with raised marks or scars, called keloids. Form of scarification, which consists of gashing, irritation by caustic juices, and sometimes the rubbing in of dark pigments for emphasis.

collagen: a protein that is the prime constituent of connective tissue, but is also found in the skin, bones, cartilage and ligaments. It has great tensile strength.

connective tissue: tissue found throughout the body. It supports, binds or separates more specialised tissues and organs.

cosmetic surgery: a subdivision of plastic surgery and a generic term for a variety of surgical procedures unrelated to disease or health and motivated by the simple personal desire to look different.

dermis: the thick layer of skin lying below the epidermis or outer layer. It is made up of connective tissue, capillaries, lymph vessels, nerve endings, sweat and sebaceous glands, hail follicles and muscle fibres.

epidermis: the outer layer of the skin, itself consisting of four layers. The epidermis constantly renews itself.

follicle: a small secretory gland.

keratin: a fibrous protein in the skin, nails and hair, which helps to flatten and harden the skin.

melanin: melanin has a protective role against ultraviolet component of sunlight.

nerve ending: distal part of a nervous dendrite. It can act as a sensitive receptor, as an element of contact and communication between nervous fibres, and also as an element of transmission of the nerve impulses.

neuron: a specialised nerve cell, which transmits electrical impulses from one part of the body to another part.

olfactory: (adj.) relating to the sense of smell. The mucous lining of the nasal cavity contains sensory cells, which are chemically stimulated. The olfactory nerve passes signals relating to smell to the brain.

Pacinian corpuscles: the touch sensors within the skin, consisting of sensory nerve endings embedded in layers of membrane.

plastic surgery: based on the Greek plastica ('to mold' or 'to form'), the term refers to surgical techniques aimed at reconstructing lost parts of the body, restoring function, or correcting acquired and/or congenital deformities (or whatever is defined as such).

receptor: an organ aterproofs the hair and skin as well as provides protection against bacteria. 18c: Latin, meaning 'grease'.

skin appendages: skin appendages include sweat glands, sebaceous glands, hair follicles, nails.

somatic: of the body, bodily

stratum corneum: the first (outer) layer of epidermis, which is waterproof and consists of flattened dead cells.

tissue engineering or biomedical engineering: science of growing living tissue in laboratories to mimic the native tissue being reconstructed for transplantation into humans. Broadly defined, tissue engineering or biomedical engineering is the development and manipulation of laboratory-grown molecules, cells, tissues, or organs to replace or support the function of defected or injured body parts. Tissue engineering crosses numerous medical and technical specialities. Cell biologists, molecular biologists, biomedical engineers, computer-assisted designers, microscopic imaging specialists, robotics engineers, and developers of equipment such as bioreactors, where tissues are grown and nurtured, are all involved in the process of tissue engineering.

TEXTILE RELATED TERMS

antibacterial: describing a textile that inhibits the growth and spread of bacteria, and remains fresh-smelling and hygienic.

antimicrobical: describing a property, in-built or in a finish, that controls the growth of bacteria and fungi for a fresh-smelling textile that prevents infection.

breathable: describing a property that allows perspiration to pass through the fabric to the outside environment. This helps maintain an even body temperature.

crêpe de chine: lightweight, plain weave crêpe fabric, made with highly twisted continuous filament yarns in the weft, alternating one S and one Z twist, and with normally twisted continuous filament yarns in the warp.

coating: a layer, usually on one side of a fabric with a performance property such as wind- or water-resistance, or that changes the look or texture.

coated fabric: material composed of two or more layers, at least one of which is a textile fabric and at least one of which is a substantially continuous polymeric layer. These are bonded closely together with an added adhesive or by the adhesive properties of one or more of the component layers.

composite: combination of two or more identifiable materials usually with improved performance characteristics.

discharge print: style of printing where a white or coloured pattern shows on a darker coloured ground. Dyed fabric is printed with a substance, the discharging agent, which removes the ground colour.

electroplating: technique for fixing a very fine deposit of metal to a material. The material to be coated is made electrically conductive and put into an acid bath, allowing a built up of metal.

flock: very short fibres, which may be coloured, that are used in flock printing.

flock print: print where areas of the cloth are first printed with an adhesive resin, and then very short fibres, known as flock, are applied by spraying or shaking. The flock adheres to the printed adhesive and, when dry, the surplus flock is removed. This gives a velvet-like surface.

geotextiles: any permeable textile materials used as an integral part of civil engineering structures of earth, rock and other constructional materials, for the purposes of filtration, drainage, separation, reinforcement or stabilisation.

handle: how a textile feels when touched with the hand, eg. warm, rough, soft, smooth, cool.

heat-transfer: a method of using heat to transfer an image from paper to textile.

industrial textiles: textile materials and products intended for end uses other than clothing, household, furnishing and floor covering. See technical textiles.

laminate: two or more materials united with a bonding material, usually with heat pressure.

latex: viscose liquid with rubber particles suspended in it. The resulting material can be moulded into many configurations which once dried are permanent.

nonwoven: term covering textile structures made directly from fibres rather than yarn. Bonding of the fibres to form a fabric is achieved by a number of methods, including adhesive bonding, mechanical bonding, thermal bonding and solvent bonding.

shielding textiles: fabrics capable of reducing electromagnetic radiation.

silicon: a non-metal element found in the earth's crust, which exists primarily as oxides and silicates. Silicon has semi-conducting properties and extreme temperature resistance. It will maintain its chemical integrity in temperatures ranging from –180°F to 600°F (-118°C to 315°C).

silicone: a synthetic polymer composed of repeating silicon and oxygen atoms with organic groups attached to the silicon. Silicone typically has low resistance properties and is water-repellent. Most types are also insensitive to temperature changes and many chemicals.

shibori: term refers to the technique of shaped resist dying through a stitch and resist process. Examples shibori are found in Japan and in other cultures.

'smart' fabrics: textiles capable of sensing and responding to external stimuli, such as changes in temperature and lightning.

spunlaid nonwoven: nonwoven fabric made from continuous filaments, which are extruded or spun and formed into a random-laid web in one process. The web is then consolidated into a fabric by adhesive bonding, mechanical bonding, thermal bonding or solvent bonding. Also known as spunbonded fabric.

technical textiles: textile materials and products manufactured primary for their technical performance and functional properties rather than their aesthetic or decorative characteristics.

thermoplastic: quality of a fibre whose molecular structure breaks down and becomes fluid at a certain temperature, making it possible to reshape the fabric by pleating, moulding, vacuum-forming or crushing. The fabric is 'fixed' on cooling and cannot be altered unless heated to a temperature greater than the one at which it was reshaped. Most synthetics are thermoplastic.

waterproof: describes a fabric or finish where there is total resistance to penetration by water, eg. PVC-coated cotton, rubberised fabric.

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INDEX OF FIGURES

Figure 77	Coloured scanning electron micrograph ® Richard Wehr in: Ewing, W. A. (1996) Inside Information. London: Thames and Hudson
Figure 78	Coloured scanning electron micrograph ® Dr. Jeremy Burgess in: Ewing, W. A. (1996) Inside Information. London: Thames and Hudson
Figure 79	Light micrograph ® Astrid Kage in: Ewing, W. A. (1996) Inside Information. London: Thames and Hudson
Figure 80	Illustration / Drawing ® Julius Ecke in: Hansen, D. (2003) Warum Sex nicht nur zum Fortpflanzen dient, P.M. Perspektive, 3/2003
Figure 81	Image in: Hamer, D. (1999) Das Wunschkind aus dem Genbaukasten, Spektrum der Wissenschaft, Special: Der High-Tech-Koerper, 4/1999
Figure 82	Andreas Vesalius in: Hagen, von G. (2000) Anatomy Art – Fascination Beneath the Surface, [Ex. cat] Heidelberg: Institute for Plastination
Figure 83	Drawing for frontispiece to Thomas Bartholin, Anatomia Reformata (Leiden, 1651) in: Connor, S. (2004) The Book of Skin, London: Reaktion Books
Figure 84	Drawing by John Browne, 1681. Credit: Wellcome Library, The Wellcome Trust, London
Figure 85	Courtesy of University of Massachusetts and Massachusetts Institute of Technology.
Figure 86	Courtesy of Organogenesis, photograph in: Lupton, E. (2002) Skin: Surface, Substance + Design. London: Laurence King Publishing
Figure 87	Photograph ® Lynn Johnson: Neffe, J., Der Fluch der guten Tat, GEO Wissen: Aerzte, Technik, Patienten
Figure 88	Collection of National Museum of American History, Smithsonian Institution, photograph in: Lupton, E. (2002) Skin: Surface, Substance + Design. London: Laurence King Publishing
Figure 89	Courtesy of German Center of Excellence for Biomaterials and Organ Replacement
Figure 90	Painting, Rembrandt, 1632 in: Hagen, von G. (2000) Anatomy Art – Fascination Beneath the Surface, [Ex. cat] Heidelberg: Institute for Plastination
Figure 91	Drawing, Leonardo da Vinci, 1510 in: Hagen, von G. (2000) Anatomy Art – Fascination Beneath the Surface, [Ex. cat] Heidelberg: Institute for Plastination
Figure 92	Photograph in: http://www.wiu.edu/users/gjr100/orlangallery.htm
Figure 93	Photograph in: http://www.orlan.net/
Figure 94	Photograph in: Hagen, von G. (2000) Anatomy Art – Fascination Beneath the Surface, [Ex. cat] Heidelberg: Institute for Plastination
Figure 95	Drawing by Juan Valverde de Hamusco, 1556. Credit: Wellcome Library, The Wellcome Trust, London
Figures 96, 97	Courtesy: the artist and Jay Jopling / White Cube. Photograph in: Gisbourne, M. (2002) The Self and others – The Art of Marck Quinn, Contemporary, February/02
Figure 98	Photograph in: Quinn, M. (2002) A Genetic Portrait, Wellcome News Supplement, Q1
Figure 99	Photography ® Richard Davis in: Lupton, E. (2002) Skin: Surface, Substance + Design. London: Laurence King Publishing
Figures 100, 101	Photography ® Daniel Nicolas in: Material World, Amsterdam: Frame / Basel, Boston, Berlin: Birkhaeuser, 2003
Figures 102 - 104	Photograph in: Stattmann, N., Ultra Light, Super Strong, Edition Form / Birkhaeuser, Basel, Boston, Berlin, 2003
Figure 105	Photography ® Daniel Nicolas in: Material World, Amsterdam: Frame / Basel, Boston, Berlin: Birkhaeuser, 2003
Figure 106	Photograph in: Lupton, E. (2002) Skin: Surface, Substance + Design. London: Laurence King Publishing
Figures 107, 108	Photograph ® Schoeller in: Schoeller advertising catalogue
Figure 109	Photography ® Daniel Nicolas in: Material World, Amsterdam: Frame / Basel, Boston, Berlin: Birkhaeuser, 2003
Figure 110	Photography ® Schoeller in: O'Mahony, M. & Braddock, S. E, (2002) Sports Tech: Revolutionary Fabrics, Fashion & Design. London: Thames & Hudson
Figures 111, 112	Photography ® Daniel Nicolas in: Material World, Amsterdam: Frame / Basel, Boston, Berlin: Birkhaeuser, 2003
Figure 113	Photograph in: Stattmann, N., Ultra Light, Super Strong, Edition Form / Birkhaeuser, Basel, Boston, Berlin, 2003
Figures 114, 115	Photography ® Sensatex in: O'Mahony, M. (2002) Cyborg: The Man-Machine. London: Thames & Hudson
Figure 116	Photography ® Nick Wilson / Allsport in: O'Mahony, M. & Braddock, S. E, (2002) Sports Tech: Revolutionary Fabrics, Fashion & Design. London: Thames & Hudson
Figure 117	Coloured scanning electron micrograph ® Science Photo Library in: O'Mahony, M. & Braddock, S. E, (2002) Sports Tech: Revolutionary Fabrics, Fashion & Design. London: Thames & Hudson
Figure 118	Photography ® Vent Design / O'Neill in: O'Mahony, M. & Braddock, S. E, (2002) Sports Tech: Revolutionary Fabrics, Fashion & Design. London: Thames & Hudson
Figures 119, 120	Photography ® Gordana Vunjak-Novakovic & Lisa Freed, Massachusetts Institute of Technology in: Langer, R. S. & Vacanti, J. P., Ersatzteilzuechtung, Spektrum der Wissenschaft Spezial – Der High.Tech-Koerper
Figure 121	Photography ® Advanced Tissue Sciences, Inc. in: Mooney, D. J. and Mikos, A. G., Organe von der Stange, Spektrum der Wissenschaft Spezial – Der High.Tech-Koerper
Figures 122, 123	Photography ® Prasad Shastri and Ivan Martin, Massachusetts Institute of Technology in: Mooney, D. J. and Mikos, A. G., Organe von der Stange, Spektrum der Wissenschaft Spezial – Der High.Tech-Koerper
Figures 124, 125	Images and photography © Architects Kramm & Strigl, advertisement catalogue, 2003
Figure 126	Image ® WOS 8 in: Lupton, E. (2002) Skin: Surface, Substance + Design. London: Laurence King

	Publishing
Figure 127	Photography ® Margherita Spiluttini in: Lupton, E. (2002) Skin: Surface, Substance + Design. London: Laurence King Publishing
Figure 128	Photograph in: Aldersey-Williams, H. (2003) Zoomorphic – New Animal Architecture. London: Laurence King Publishing
Figure 129	Photography ® Nicholas Grimshaw in: Future Materials for Architecture and Design. [ex.cat] Materia, Rotterdam, 2002
Figure 130	Photograph in: Aldersey-Williams, H. (2003) Zoomorphic – New Animal Architecture. London: Laurence King Publishing
Figure 131	Illustration ® Outlast in: O'Mahony, M. & Braddock, S. E, (2002) Sports Tech: Revolutionary Fabrics, Fashion & Design. London: Thames & Hudson
Figure 132	Photography ® Dr. Klaus Hausman, 2001
Figures 133, 134	Photography ® Berzina, Z., 2003
Figure 135	Photograph in: Corcuff, P. & Leveque, J.-L. (1993) Age-Related Changes in Skin Microrelief Measured by Image Analysis, Leveque, J.-L. & Agache, P. ed. Aging Skin – Properties and Functional Changes, New York: Marcel Dekker, Inc.
Figures 136 - 139	Light micrographs ® Berzina, Z., 2001
Figure 140	Photography ® Berzina, Z., 2002
Figure 141	Scanning electron micrograph ® Berzina, Z., 2001
Figure 142 - 144	Images in: Xie, Y. & Mignot, J. (1993) Measurment of Skin Relief by Two- and Three-Dimensional Profilometry, Leveque, J.-L. & Agache, P. ed. Aging Skin – Properties and Functional Changes, New York: Marcel Dekker, Inc.
Figures 145 - 147	Polaroid photographs and light micrographs ® Berzina. Z., 2001
Figures 148, 149	Scanning electron micrographs ® Berzina, Z., 2001
Figure 150	Illustration in: Corcuff, P. & Leveque, J.-L. (1993) Age-Related Changes in Skin Microrelief Measured by Image Analysis, Lèveque, J.-L. & Agache, P. ed. Aging Skin – Properties and Functional Changes. New York: Marcel Dekker, Inc.
Figure 151	Light micrograph ® Berzina, Z., 2002
Figure 152	Photography ® Berzina, Z., 2002
Figure 153	Berzina, Z.
Figures 154, 155	Photograph in: http://archrecord.construction.com/innovation/4_Products/images/0310_12.jpg
Figures 156 - 160	Illustrations ® Berzina, Z.
Figures 161 - 171	Photography ® Berzina, Z., Design: Berzina, Z., 2002 - 2003
Figure 172	Photography ® Charmed Technology 2000 in: Quinn, B. (2002) Techno Fashion. Oxford, New York: Berg
Figures 173 - 175	Illustrations ® Berzina, Z.
Figures 176, 177	Photography ® Berzina, Z, 2002.
Figures 178, 179	Light micrographs ® Berzina, Z, 2002
Figures 180 - 230	Photography ® Berzina, Z., Design: Berzina, Z., 2002 - 2003
Figure 231	Illustration in: Corcuff, P. & Leveque, J.-L. (1993) Age-Related Changes in Skin Microrelief Measured by Image Analysis, Leveque, J.-L. & Agache, P. ed. Aging Skin – Properties and Functional Changes. New York: Marcel Dekker, Inc.
Figures 232 - 240	Photography ® Berzina, Z., Design: Berzina, Z., 2002 - 2003
Figure 241	Photograph ® David Barlow in: Smith, A. (1998) The Human Body. London: BBC Books
Figure 242	Photography ® Berzina, Z., Design: Berzina, Z., 2003
Figure 243	Photography in: Hagen, von G. (2000) Anatomy Art – Fascination Beneath the Surface, [Ex. cat] Heidelberg: Institute for Plastination
Figure 244	Photography ® Berzina, Z., Design: Berzina, Z., 2003
Figure 245	Credit ® Medical Photo Library, The Wellcome Trust, London
Figure 246	Photography ® Berzina, Z., Design: Berzina, Z., 2003
Figure 247	Credit ® Medical Photo Library, The Wellcome Trust, London
Figure 248	Photography ® Berzina, Z., Design: Berzina, Z., 2003
Figure 249	Scanning electron micrograph ® Berzina, Z., 2001
Figure 250	Photography ® Berzina, Z., Design: Berzina, Z., 2003
Figure 251	Scanning electron micrograph ® Berzina, Z., 2001
Figure 252	Photography ® Berzina, Z., Design: Berzina, Z., 2003
Figure 253	Illustration in: Corcuff, P. & Leveque, J.-L. (1993) Age-Related Changes in Skin Microrelief Measured by Image Analysis, Leveque, J.-L. & Agache, P. ed. Aging Skin – Properties and Functional Changes. New York: Marcel Dekker, Inc.
Figures 254 - 290	Photography ® Berzina, Z., Design: Berzina, Z., 2002 - 2003
Figures 291, 292	Light micrographs ® Berzina, Z.
Figures 293 - 303	Photography ® Berzina, Z., Design: Berzina, Z.

INDEX OF TABLES